A. SIEBE'S

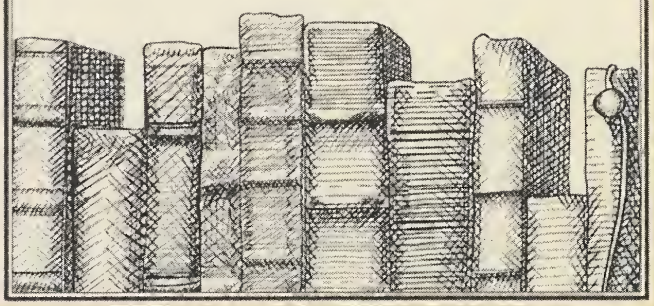
DIVING APPARATUS

WITH

INSTRUCTIONS FOR SUBMARINE OPERATIONS

BY

SIEBE & GORMAN.



Capt D. Chisholm

Underwriters Surveyor

ILLUSTRATED & DESCRIPTIVE CATALOGUE.

A. SIEBE, INVENTOR OF THE CLOSE DIVING DRESS.

Established 1820.

SIEBE & GORMAN, London.

SUBMARINE & HYDRAULIC ENGINEERS & MACHINISTS.

MANUFACTURER OF DIVING APPARATUS TO THE LORDS OF THE ADMIRALTY, THE BOARD OF ORDNANCE, THE EAST INDIAN GOVERNMENT, AND THE ROYAL ENGINEERS' SCHOOL OF MILITARY ENGINEERING; ALSO TO THE FRENCH, RUSSIAN, SWEDISH, NORWEGIAN, TURKISH, GREEK, SPANISH, ITALIAN GOVERNMENTS, AND OTHER MARITIME POWERS, AND TO THE PONTS ET CHAUSSÉES OF FRANCE.

INVENTOR, PATENTEE, AND MANUFACTURER OF THE

ROTATORY HYDRAULIC ENGINE PUMP.

MANUFACTURER OF

ICE-MAKING & REFRIGERATING MACHINES,

And all kinds of Machinery connected with Pneumatics.

LATHES, TOOLS, MODELS, & STEAM ENGINES.

WELLS FITTED WITH PUMP & PUMPING GEAR.

Heating by Steam in all its Branches.

GAS FITTING AND GENERAL KITCHEN WORK.

INVENTOR AND MANUFACTURER OF

Union Connecting Joints, Dial Weighing Machine, & Sportsman's Scales

IMPROVED SELF-ACTING SUPPLY & PATENT SELF-PRESSURE BOILER COCKS.

Voltaic Batteries and Frictional Machines for Blasting Under Water.

SHIP RAISING & SUBMARINE OPERATIONS UNDERTAKEN.

5, DENMARK STREET, SOHO, LONDON, W.C.

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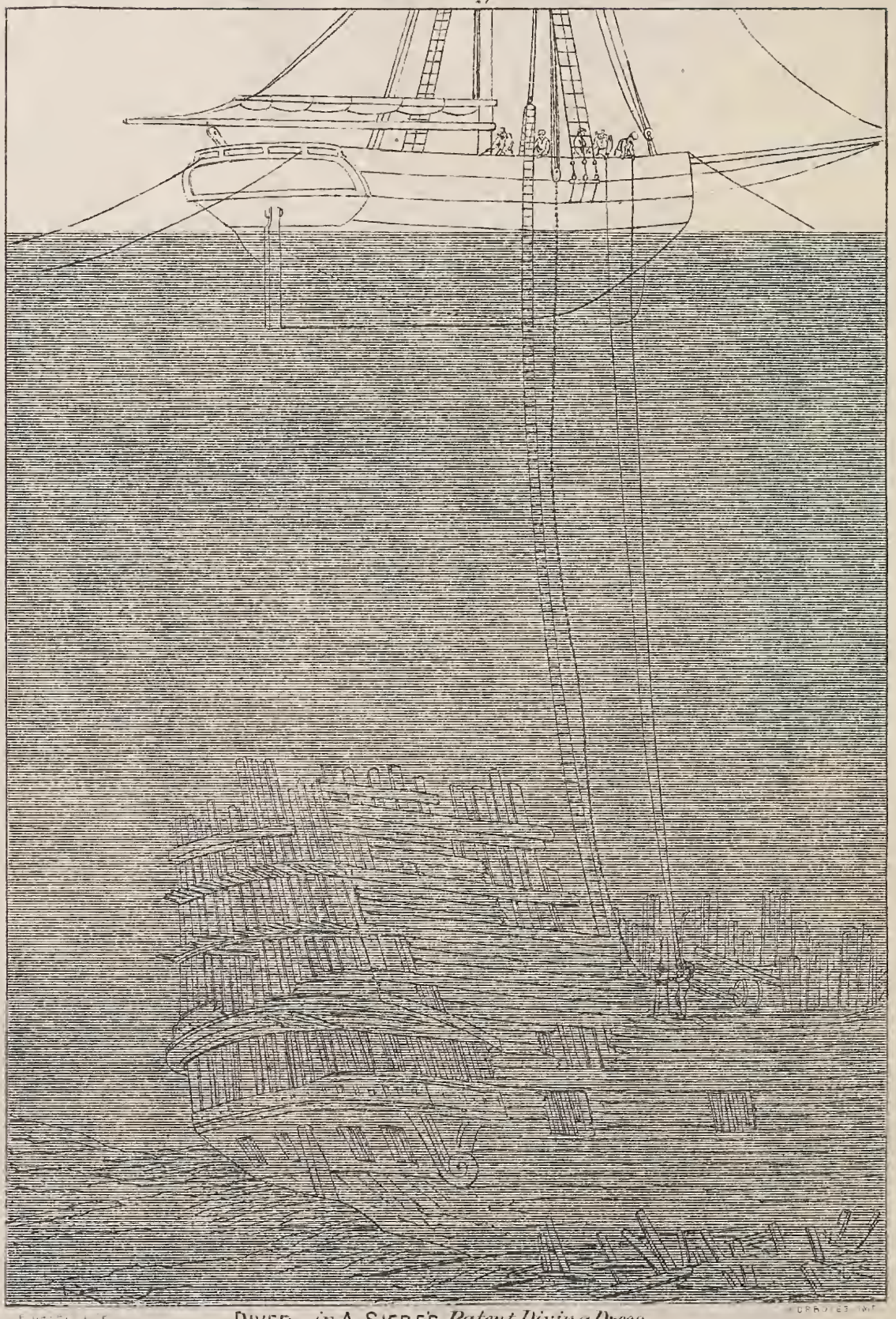
"Wreck of the "Royal George."

SIEBE & GORMAN,

Submarine Engineers.



DIVER, *in* A. SIEBE'S, *Patent Diving Dress*

RECOVERING GUNS ON THE WRECK OF THE ROYAL GEORGE.

5, DENMARK ST. SOHO, LONDON.

TESTIMONIALS.

Admiralty, 4th May, 1840.

Sir,—I have to desire, in pursuance of the directions of the Lords Commissioners of the Admiralty, that you will forward a Diving Apparatus as soon as possible to the Admiral Superintendent of the Dockyard, Portsmouth, for the use of Colonel Pasley, at Spithead.

I am sir, your humble servant,

To A. Siebe. R. Dundas, *Storekeeper-General of the Navy.*

Note.—Since the above date we have constantly supplied the Lords of the Admiralty.

London, the 10th of September, 1845.

I do hereby certify that Mr. Siebe, of 5, Denmark Street, Soho, made the most approved Diving Apparatus, including Helmets, Dresses, Air Pumps, &c., that were used in removing the wrecks of the Royal George, and of the Edgar, at Spithead; and that I found his apparatus much superior to those of Mr. Dean and of Mr. Bethell, which were used the first year of these operations, before I became acquainted with Mr. Siebe's improvements. I have recommended his Diving Apparatus to the Lords Commissioners of the Admiralty, to the Master-General, and Board of Ordnance, and to every person who has applied to me for information on the subject of diving. His workmanship is particularly good, and I found him punctual and attentive in the execution of orders.

C. W. Pasley, *Major-General.*

TESTIMONIAL.

Chatham, December 11th, 1868.

Mr. Siebe,—I am happy to inform you that the Diving Apparatus behaved admirably: the pumps remained at one time for three weeks without any cleaning or attention, often wet with salt water and receiving rough usage, but they did their work to perfection, and have not sustained the slightest damage. On three occasions the diver got entangled in loose cordage and timber of the wreck, but experienced no difficulty in cutting himself free.

H. Jekyll, *Lieut. R.E.*

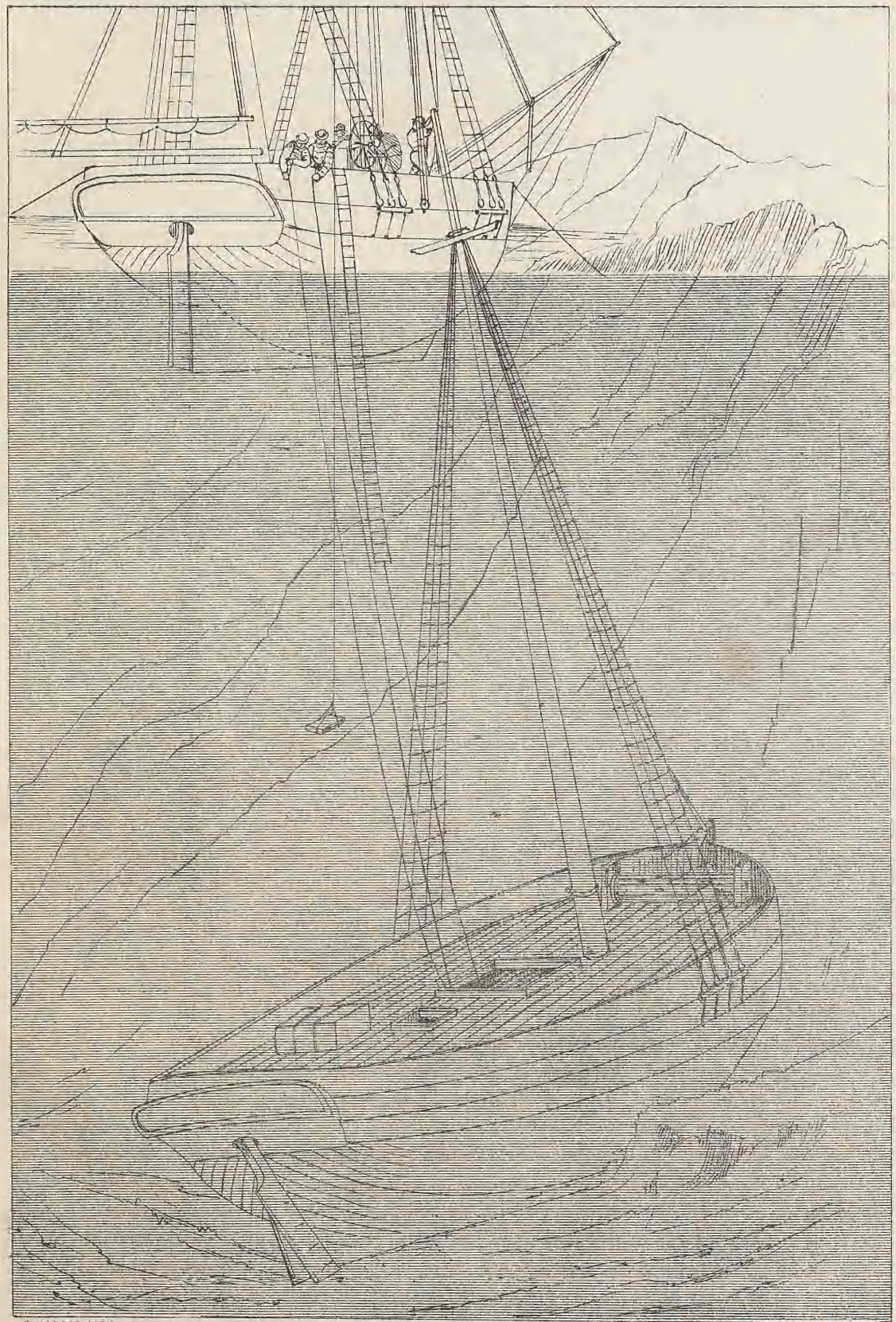
EXTRACT.

"*Times*," *January 1st*, 1870.

Diving Operations of the Royal Engineers.—The diving operations carried on by the Royal Engineers at the School of Military Engineering, Chatham, have been brought to a close for this season. During the past six months about eighty men have been trained, under Colour-Sergt. R. Baker, and passed for divers. Colonel Lennox, C.B., V.C., has adopted excellent means of giving the men of the corps a thorough practical experience in submarine explosions. In carrying out this plan a party of sappers and miners under command of Lieuts. H. Jekyll and G. W. Addison have recently completely cleared away the emigrant ship Lichardt, which was sunk at the Nore, and formed a great hindrance to the navigation of the river. The five charges used on this occasion were so placed and connected that they were fired simultaneously by electricity, the result being the total destruction of the ship. Several improvements in the diving dress have lately been made, rendering it more efficient. During the training of his Royal Highness Prince Arthur with the Royal Engineers, his Royal Highness more than once took part in the diving operations, and made descents fully equipped in Mr. Siebe's diving dress.

SIEBE & CORMAN,

Submarine Engineers.



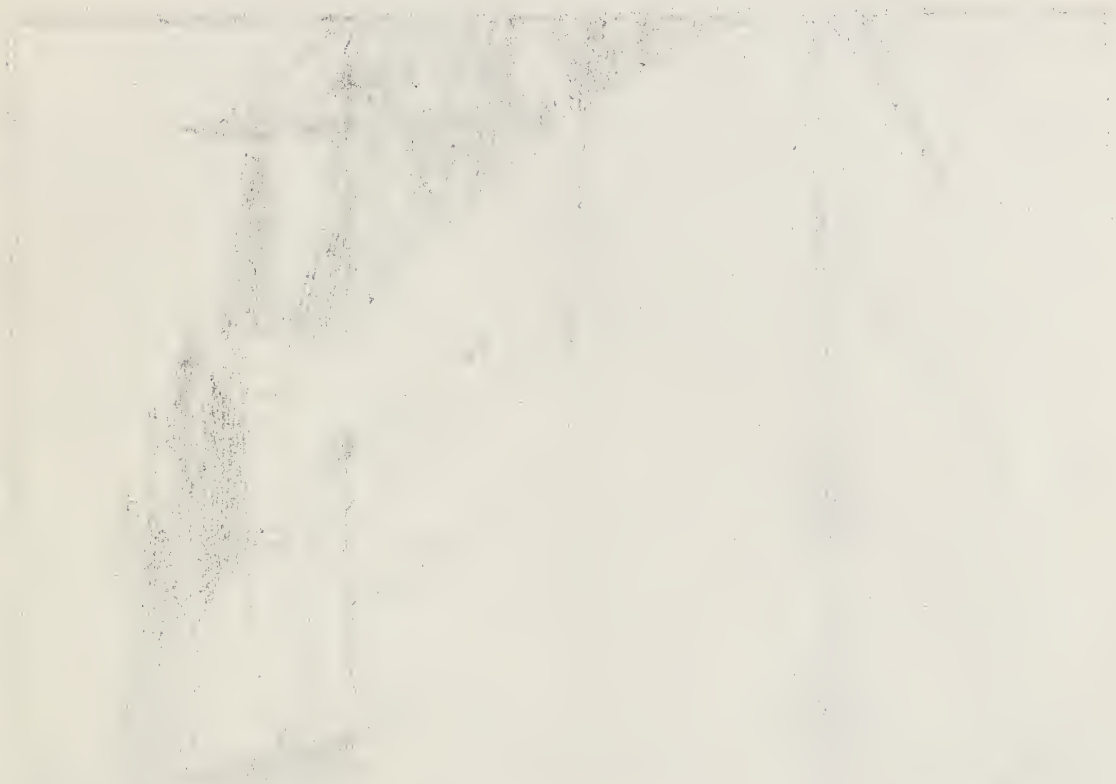
F. HARRIS, LITH.

WORSOYES IMP.

DIVER, *in* A. SIEBE'S *Patent Diving Dress.*

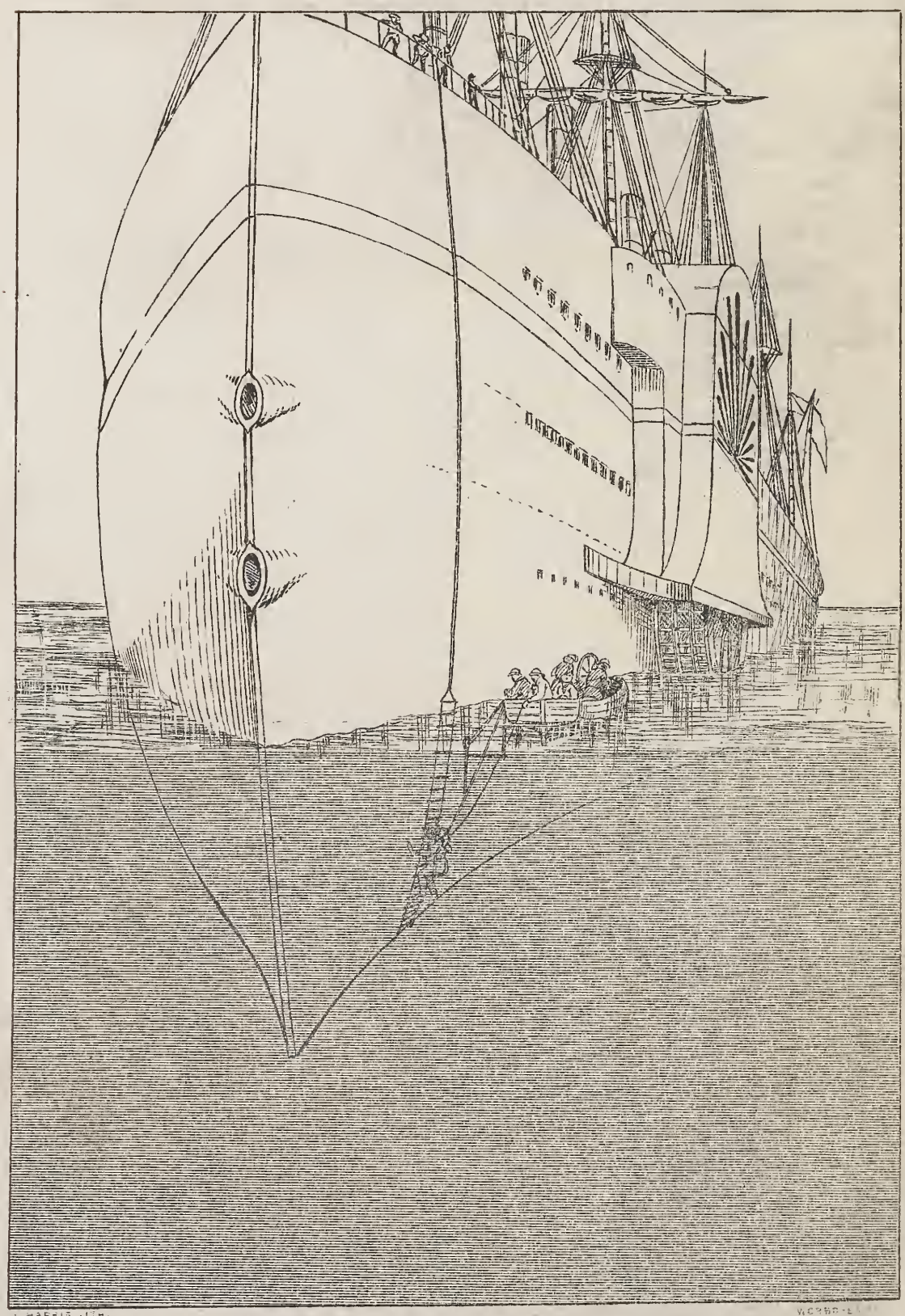
REMOVING CARGO FROM SUNKEN VESSEL.

5 DENMARK ST. SOHO. LONDON.



SIEBE & CORMAN,

Submarine Engineers.



DIVER. *in* A. SIEBE'S, *Patent Diving Dress.*

CLEANING BOTTOM OF GREAT EASTERN.

5, DENMARK ST. SOHO, LONDON.

TESTIMONIAL.

Telegraph Construction and Maintenance Company, Limited.
Offices, 38, Old Broad Street, London.

MESSRS. SIEBE AND COMPANY. *Feb. 7th*, 1870.

GENTLEMEN,—I hereby certify that the divers under your superintendence did thoroughly clean the bottom of the Great Eastern from an accumulation of weeds and mussels about one foot in thickness, which could not have been otherwise reached without placing her on a gridiron—an operation which would have entailed great expense and risk, apart from inconvenient delay.

From Captain Halpin's report, I believe the speed of the ship to have improved a knot and a half an hour, on the same consumption of fuel as was used during her recent Atlantic voyage.

I remain, Gentlemen, yours obediently,

SHERARD OSBORN, *Captain R.N.*,
Managing Director.

EXTRACT.

"*Times*," *December 6th*, 1865.

The Racer, Commander L. Brine, since her arrival from the Ionian Islands, has been placed in the hands of the divers of her Majesty's ship Victoria, who were equipped in Mr. Siebe's Diving Dress, for the purpose of having her bottom cleaned of an accumulation of weed and shell-fish which had formed on it during the twelve months she has been in commission.

TESTIMONIAL.

H.M. Dockyard, Chatham,

MR. SIEBE. *Feb. 14th,* 1870.

SIR,—I have now been using your Diving Apparatus for twenty-five years. I have had a trial of all others that are now in use, but I can safely say that yours is not only the safest but the best that I have ever seen.

EDWIN HAWTHORNE, *Admiralty Diver.*

EXTRACT.

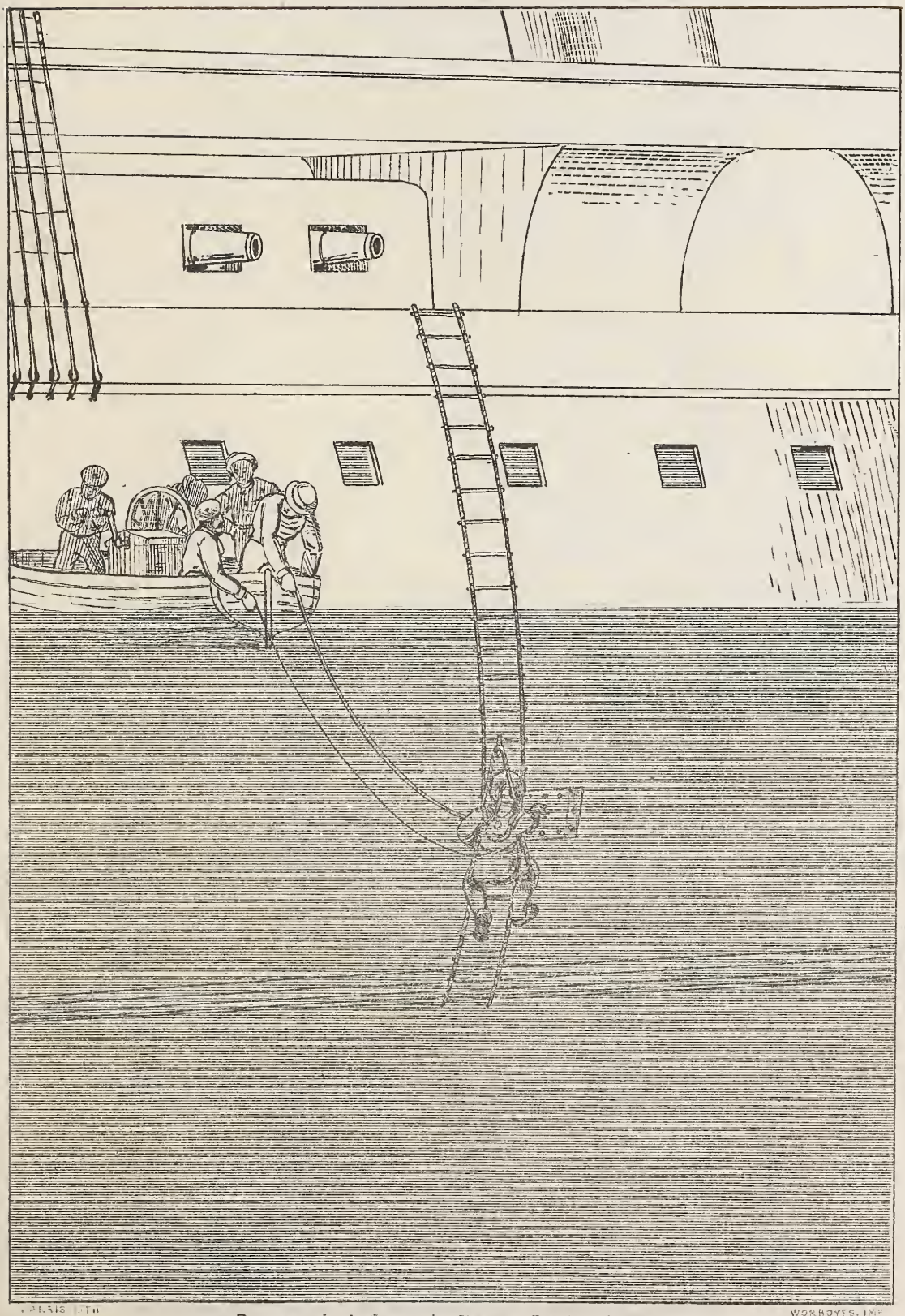
"Illustrated London News," November 18th, 1854

The following is an extract from our Correspondent's letter:—

When the Agamemnon was engaging the formidable Fort Constantine on the 17th—the place appropriated for the wounded being the gunner's store-room, in the fore part of the ship, some distance below water, to ensure their safety; the surgeon was in the act of amputating the right arm of the Admiral's valet, who had unfortunately been struck by a shot under the poop, when a very heavy blow appeared to have struck the ship under water in the fore part, the concussion causing the displacement of a number of stores, &c., in the store-room, at the same time unseating the clergyman of the ship, who was assisting in the operation. At the moment, it was thought a shot or shell had pierced through under water, but on the ship being careened on the following day to stop the shot-holes no and under the water line, no mark could be traced in that particular place; but, five days afterwards, the diver was sent down with Siebe's apparatus, to examine the ship's bottom further under water, and, to his astonishment, found in the port bow, about twelve feet under water, a large rocket sticking in the bottom of the ship, which had there exploded, doing much damage, and which must have caused the concussion felt in the gunner's store-room by the surgeon and his assistants. The rocket was so firmly fixed, that the diver could not extricate it, and was compelled to break it short off. A similar one burst also on the quarter-deck of the Agamemnon.

SIEBE & CORMAN,

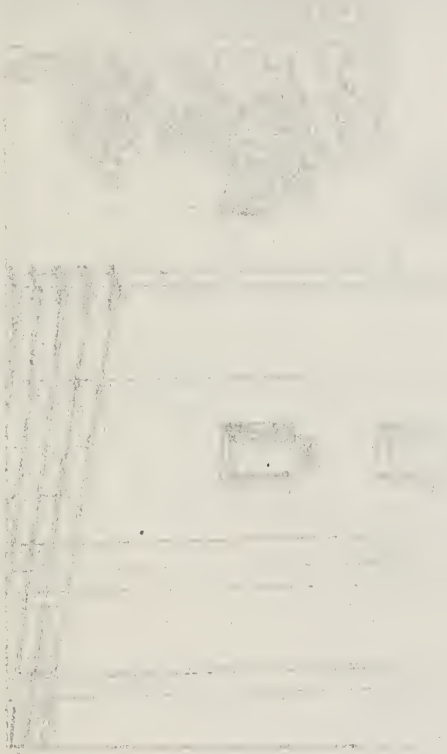
Submarine Engineers.



DIVER. *in* A. SIEBE'S *Patent Diving Dress.*

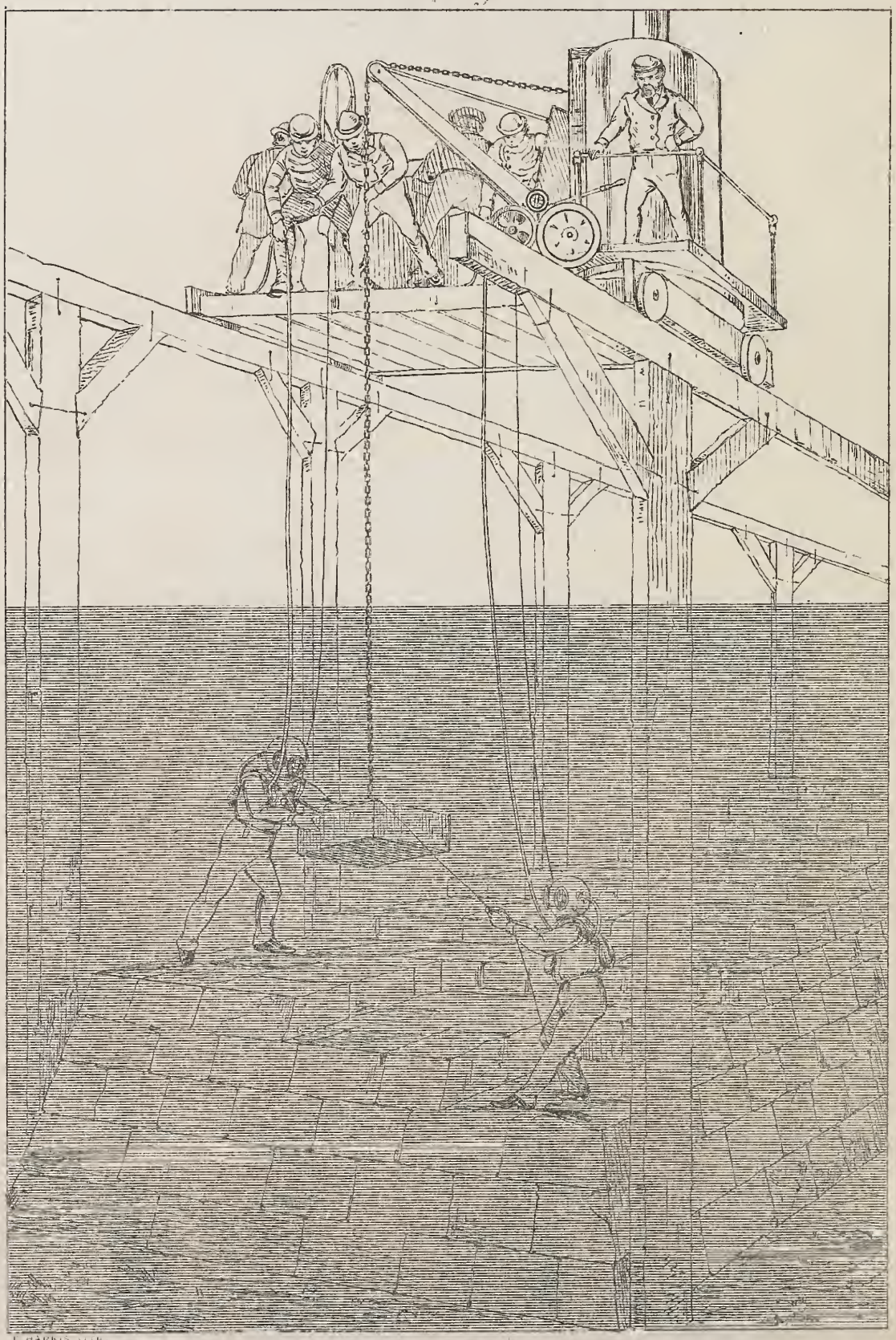
CLEANING PORT VALVE OF IRON CLAD.

5, DENMARK ST. SOHO, LONDON.



SIEBE & GORMAN,

Submarine Engineers,



DIVERS, *in* A. SIEBE'S, *Patent Diving Dress,*
PIER & BREAKWATER BUILDING.

5 DENMARK ST. SOHO. LONDON.

TESTIMONIALS.

14, *Park Street, Westminster, S.W.*,
15*th January*, 1870.

From my general knowledge of the excellence of Mr. Siebe's Diving Apparatus, I recommend the Secretary of State to order from that gentleman the apparatus necessary for the Kurrachee Harbour Works, and which is now in use there.

W. PARKES, *M. Inst. C.E.*,

Consulting Engineer to the Government for Kurrachee Harbour Works.

SIEBE'S DIVING APPARATUS.

Holyhead Harbour and Breakwater,
January 21*st*, 1870.

MESSRS. SIEBE.

GENTLEMEN,—We have the pleasure in replying to your letter of the 19th inst., and have to state that we consider the capabilities of the Diving Helmet and Dresses that you manufacture are most practical and serviceable for all descriptions of divers' work, whether in shallow or deep water.

During the period of the last twenty years or so, in which we have been engaged in submarine working at these works (without a single accident to life or limb of the divers employed), we have used your description of Diving Apparatus in preference to any other, and continue to do so, being so well satisfied with it, both on account of its efficiency for its work and safety for the divers engaged.—Yours faithfully,

R. L. COUSENS, *Superintendent.*

For MESSRS. RIGBY AND CO.

EXTRACT.

"Chatham News," December 26th, 1868.

SUBMARINE OPERATIONS BY ROYAL ENGINEERS.—The Royal Engineers have just terminated their diving operations for the season. During the past six months the men have been taught diving in the Medway under an excellent system arranged by Colonel W. O. Lennox, C.B., V.C., Royal Engineers, with an improved Diving Apparatus invented by Mr. A. Siebe, submarine engineer, and manufacturer of Diving Apparatus to the Royal Navy and Engineers. The operations carried out have been most interesting, and must prove a great advantage as regards the clearance of wrecks from the rivers and channels.

During the month of August last a diving party was sent from Woolwich to Chatham to blow up the wreck of the iron steamship Foyle, sunk through collision. The charges on the occasion were placed by Sergeant Baker, R.E.; the men were under the direction of Lieut. H. Jekyll, R.E., who descended to ascertain that the charges were properly fixed; the result was the demolition of the vessel; the massive cast-iron beams, which supported the machinery, were cracked and broken in several places.

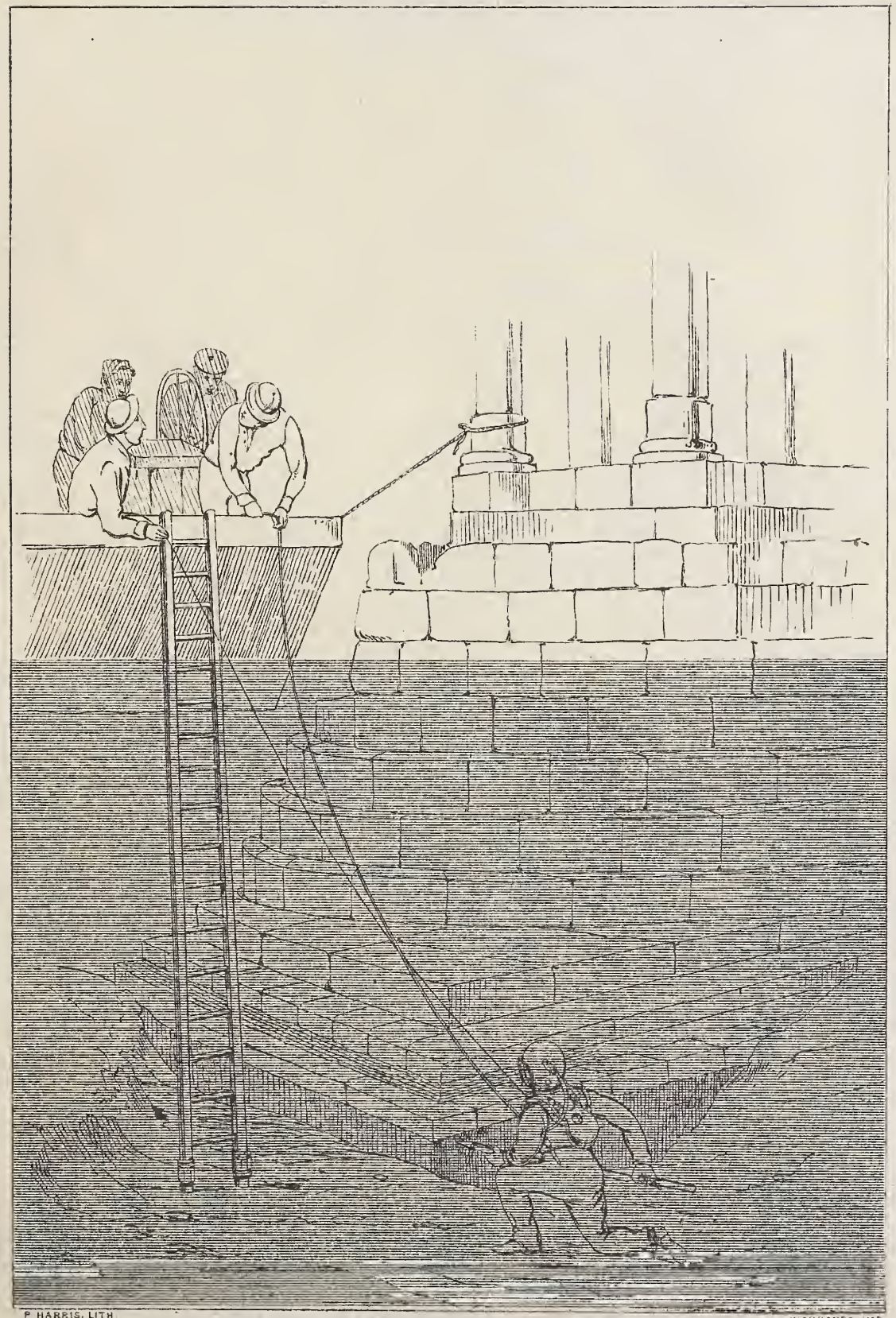
During the past month the same party, and in command of Lieut. Jekyll, have been engaged blowing up the wreck of the Irides, sunk in the vicinity of the "Cant" Sands, at the Nore. Charges used on this occasion were prepared at the torpedo department of the Royal Engineer Establishment, Chatham, in water-tight cases, each charge being 60lbs. of compressed newly-invented gun-cotton, being equal in power to 300lbs. of gunpowder. Owing to the wild state of the weather, a heavy sea was running, which rendered the task no easy matter, especially as the men worked from a steam-launch, and the great motion was an impediment to the operations. The diver (Sergeant Baker) worked under great disadvantages, as it was quite dark at the bottom, and a quantity of loose wreck was found. On his first descent, in a strong tide, he discovered a rope on the port side, which passed under the ship; to this he fixed a charge. The electric cable having been previously spliced on, it was fired by the frictional machines. A great quantity of wreck came up from the explosion. The next day, the weather being more moderate, he took down iron staples, and drove them into the ship's quarters on the starboard and port sides. He was unlucky enough to fall into a hole, five feet deep, caused by the first explosion, but, giving the signal, he was hauled out by the life-line. He then fired the charges in three respective places, which were connected so as to be fired simultaneously in continuous circuit. The explosion was most successful. A vast column of water shot up 80 feet high, carrying with it pieces of timber, spars, &c., and a mass of black mud came rolling up from the bottom, carrying with it the ship's ribs, planking, cordage, &c.

Too much praise cannot be given to Lieut. Jekyll, R.E., and his men for the admirable manner in which the operations have been carried out. One of the great advantages of the Diving Apparatus used is that should the diver get foul and be unable to clear himself, a second diver can be sent down from the same pump. The invention has been tried in very deep water near the Downs from the deck of H.M. steam-vessel Adder, Mr. W. Blakey Master Commander, in connection with the submarine light invented by Mr. Siebe.

The next undertaking by the Royal Engineers will be the blowing-up the wreck of the ship Liechardt, which has been recently sunk near the "Wharp" Sands, at the Nore, by the steamship North Star. It is understood that the Royal Engineers will be employed in removing wrecks both in the Channel and the Thames and Medway on all future occasions.

SIEBE & GORMAN,

Submarine Engineers.



P. HARRIS, LITH

WORBOYES IMP.

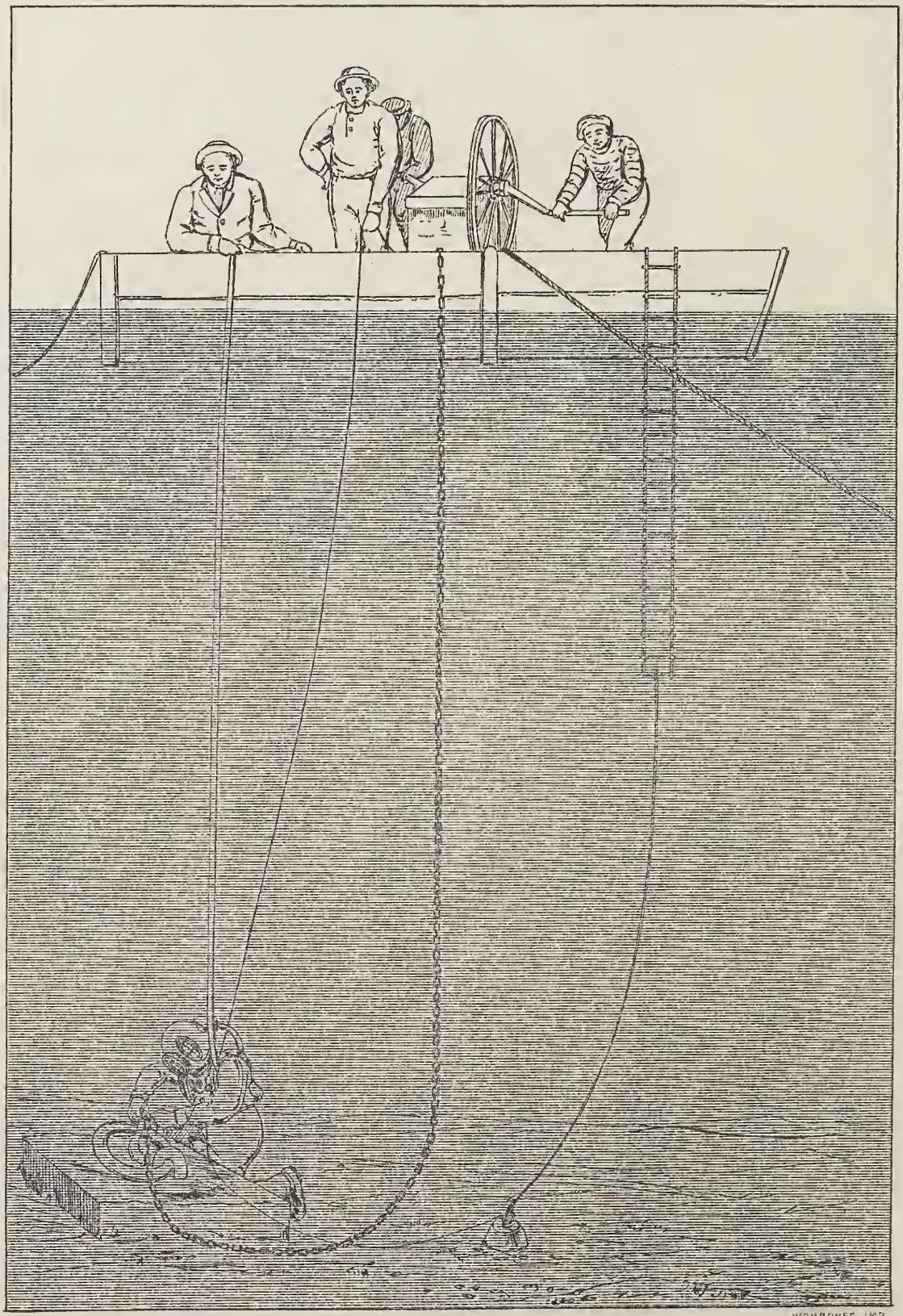
DIVER. *in* A. SIEBE'S, *Patent Diving Dress.*

REPAIRING FOUNDATION OF BRIDGE.

5, DENMARK ST. SOHO, LONDON.

SIEBE & CORMAN,

Submarine Engineers.



F. HARRIS. LITH. WORBOYES. IMP.

DIVER'. *in* A. SIEBE'S, *Patent Diving Dress.*

LAYING MOORINGS.

5, DENMARK ST. SOHO, LONDON.

TESTIMONIAL.

H.M. Dockyard, Portsmouth, January 24th, 1870.

Sir,—I beg to state I have used your Diving Apparatus since 1844, and it has always given me the greatest satisfaction, and I am now using the same for all Government uses. I have also used the French Diving Apparatus for trial, and must certainly give the greatest preference to your invention. I have endeavoured to persuade those interested that I can fully carry out the work consigned to me with your invention better than with any other I have ever used.

I remain, Sir, yours truly,

George Hardy, *Admiralty Diver.*

EXTRACT.

"*Express,*" *May* 30*th*, 1868.

Admiralty Divers.—The Admiralty have organised a corps of divers under the superintendence of their submarine engineer, Mr. Siebe. Any young A.B. seamen who wish to learn to dive are drafted off for instruction to the Excellent, in Portsmouth harbour, where they are instructed by Mr. George Hardy, the chief diver of Portsmouth dockyard, who has been for twenty years in the service, and has worked at a depth of 160 feet. When the men are considered competent they are commissioned to some vessel—each vessel on service carrying a diver, who is classed as a petty officer. Their business is to repair any damage to the ship's bottom, to examine the screw propeller and the cable if necessary, and so on. Some of the vessels on foreign stations have rendered essential service by lending their men and apparatus for the recovery of the mails when an accident has happened to a mail steamer. If we are not mistaken, it is now the practice of the Board of Trade to see that a diver is appointed to all the seaports in the kingdom.—*Cornhill Magazine* for June.

TESTIMONIALS.

Works Office, Dundee Harbour,
October 5, 1869.

I have great pleasure in testifying to the goodness of Messrs. Siebe and Co's Diving Apparatus, which I have had in use at this Harbour for a number of years back.

CHARLES OWER, C.E.,
Dundee, N.B.

Caledonian Canal, Fort Augustus,
January 8th, 1869.

A. SIEBE, ESQ.

DEAR SIR,—The Diving Apparatus (we got by the late G. May, Esq., C.E.) we consider a first-rate article. I had seven and a half hours' work in one day about our lock-gates here, and, indeed, it is now considered the most valuable article on this line of navigation.

I am, dear Sir,
Very truly yours,
JOHN MCBEAN.

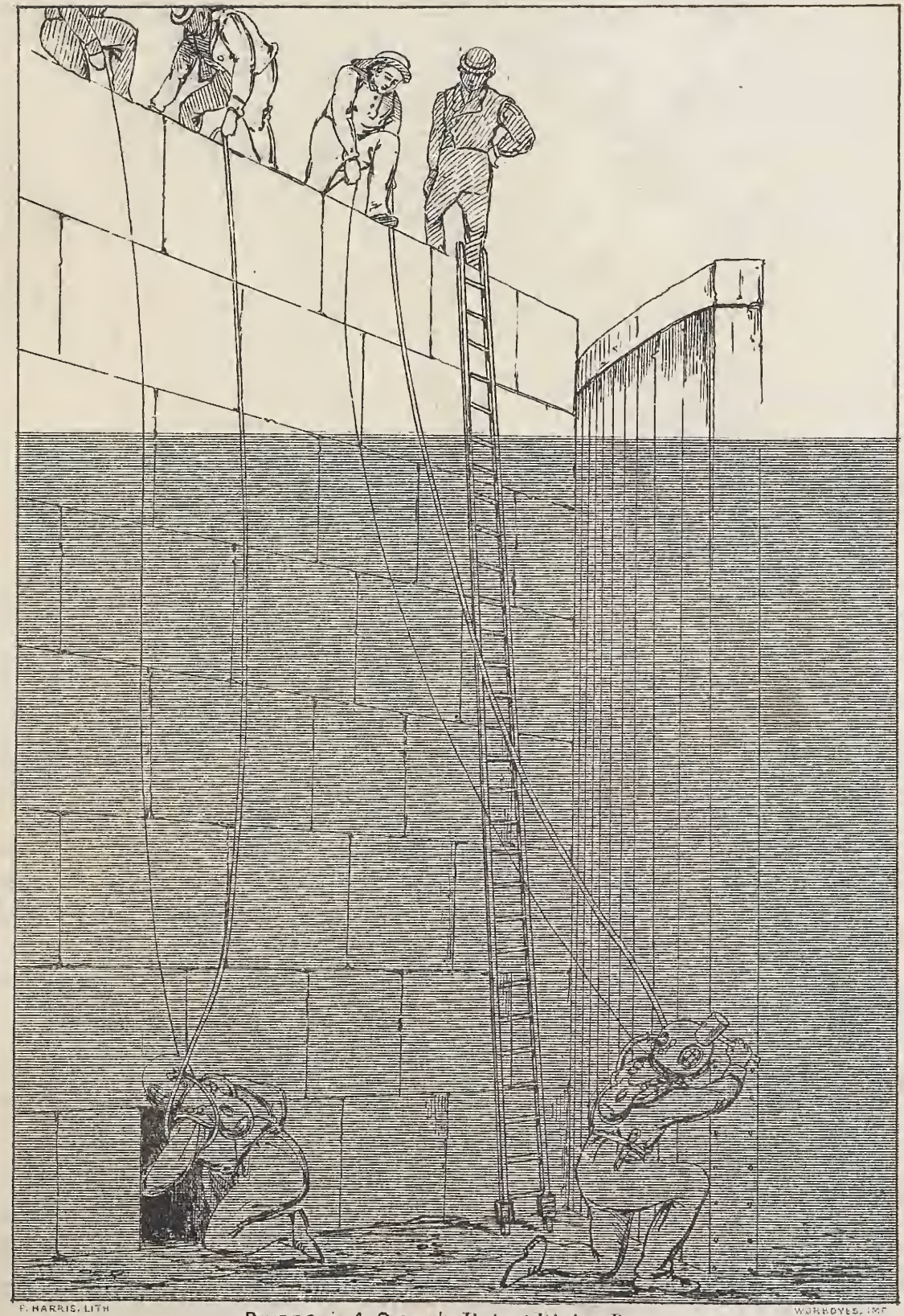
EXTRACT.

Extract from the Parliamentary Report of the Caledonian Canal by the late G. May, Esq., C.E.

The Diving operations personally carried out by our travelling superintendent, Mr. McBean, in the Diving Dress (manufactured by Mr. Siebe) have been so effectually done, that when anything occurred to the lock-gates he has remained for six hours under water until the work was completed and in proper working order.

SIEBE & GORMAN,

Submarine Engineers.



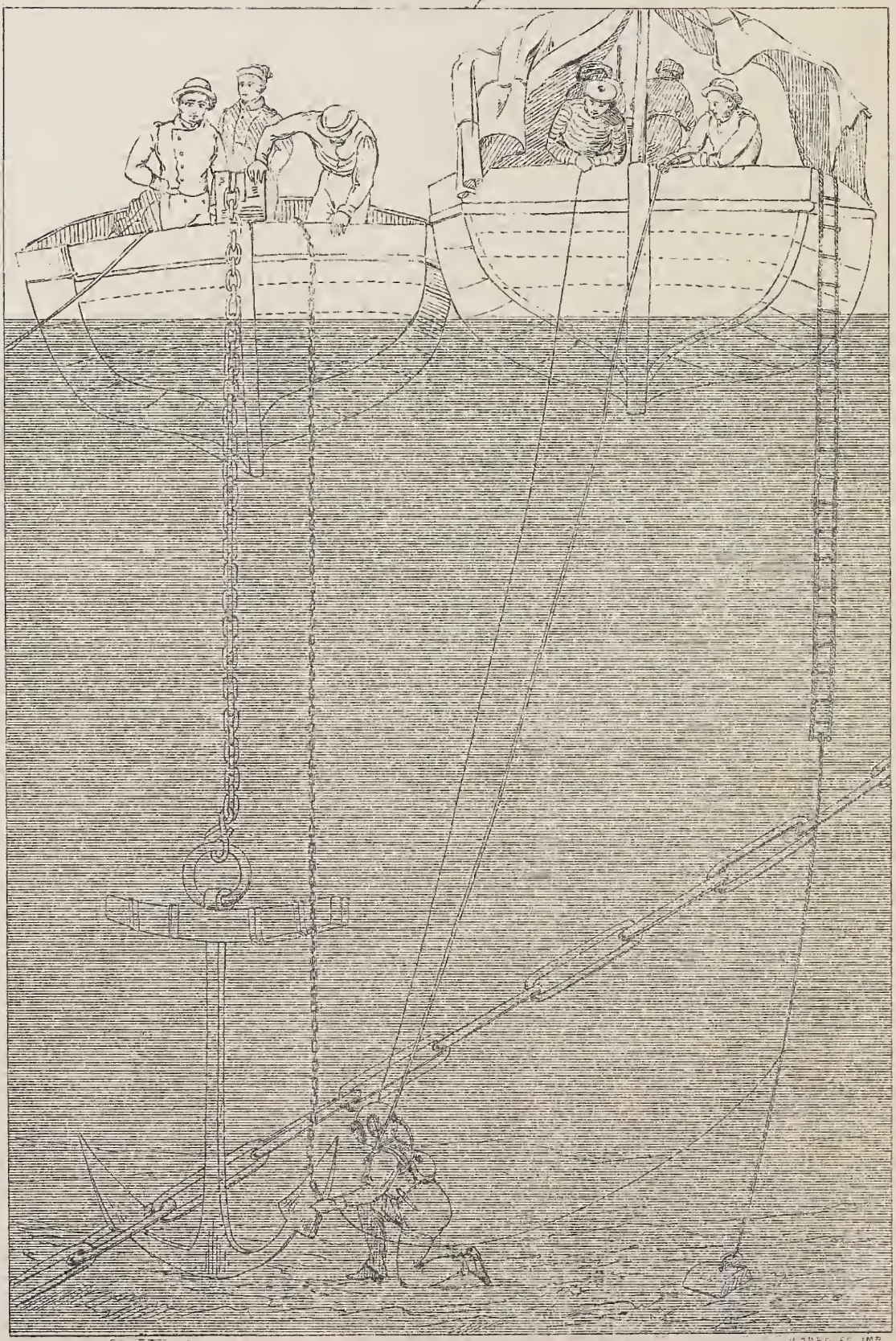
F. HARRIS, LITH. WORBOYES, IMP.

DIVERS *in* A. SIEBE'S *Patent Diving Dress*,
REPAIRING DOCK GATES AND SLUICE.

5, DENMARK ST. SOHO, LONDON.

SIEBE & GORMAN,

Submarine Engineers.



P. HARRIS, LITH.

DIVER, *in* A. SIEBE'S *Patent Diving Dress*
RECOVERING ANCHOR.

5, DENMARK ST. SOHO, LONDON

EXTRACT.

"*Times*," *May 20th*, 1868.

Yesterday some valuable experiments were made at Chatham, under the direction of Colonel W. O. Lennox, C.B., V.C., instructor in field fortifications and submarine engineering at the Royal Engineer establishment, for the purpose of testing the merits of a new application of the Diving Apparatus, invented by Mr. Siebe, submarine engineer to the Royal Navy, by which two divers can be sent down in any depth of water, and supplied with air from the same pump. The Adder, paddle-wheel steamer, Mr. Blakey master commander, having the party of divers on board, steamed out of the harbour to reach the required depth of water, when the Admiralty diver employed at Chatham Dockyard descended, by means of the apparatus, to a depth of 60 feet, followed immediately after by Lieut. T. Fraser, Royal Engineers, who made his descent for the first time. Air was supplied to both the divers by means of one cylinder, and after walking a considerable distance and remaining under water some time, the divers returned to the surface, both stating that they were furnished with abundance of air, while neither suffered the slightest inconvenience. Not the least of the advantages of Mr. Siebe's invention is the fitting of the diving apparatus with a self-acting pressure gauge, which registers the pressure in pounds, while a submarine lamp can also be applied to the pump, by which means the driver can be assisted by a steady light when employed in exploring the interior of a vessel, or descended to any depth to which the light of day does not penetrate. The Admiralty diver subsequently descended to the great depth of 108 feet with the two cylinders of the air-pump connected, followed to the same depth by Sergeant Baker, of the Royal Engineers, who made his first descent, when even at the depth and under the conditions stated, not the least inconvenience was experienced by either of the divers, who remained down for some time, the valves, gauge, register, and other parts of the apparatus all working most satisfactorily. The officers and men at the Royal Engineer establishment will commence their summer course of practice in diving operations with Mr. Siebe's apparatus and the improved air-pump.

The Admiralty diver, Mr. Hawthorne, who has been diving for the service twenty-five years with Mr. Siebe's diving dress, expressed his regret that deeper water could not be found at Sheerness; as the apparatus worked so well he was prepared to dive to the depth of 160 feet.

TESTIMONIAL.

No. 2, Bond Court, Walbrook, London, E.C.,

Feb. 14th, 1870.

Mr. A. Siebe, 5, *Denmark Street, Soho, W.C.*

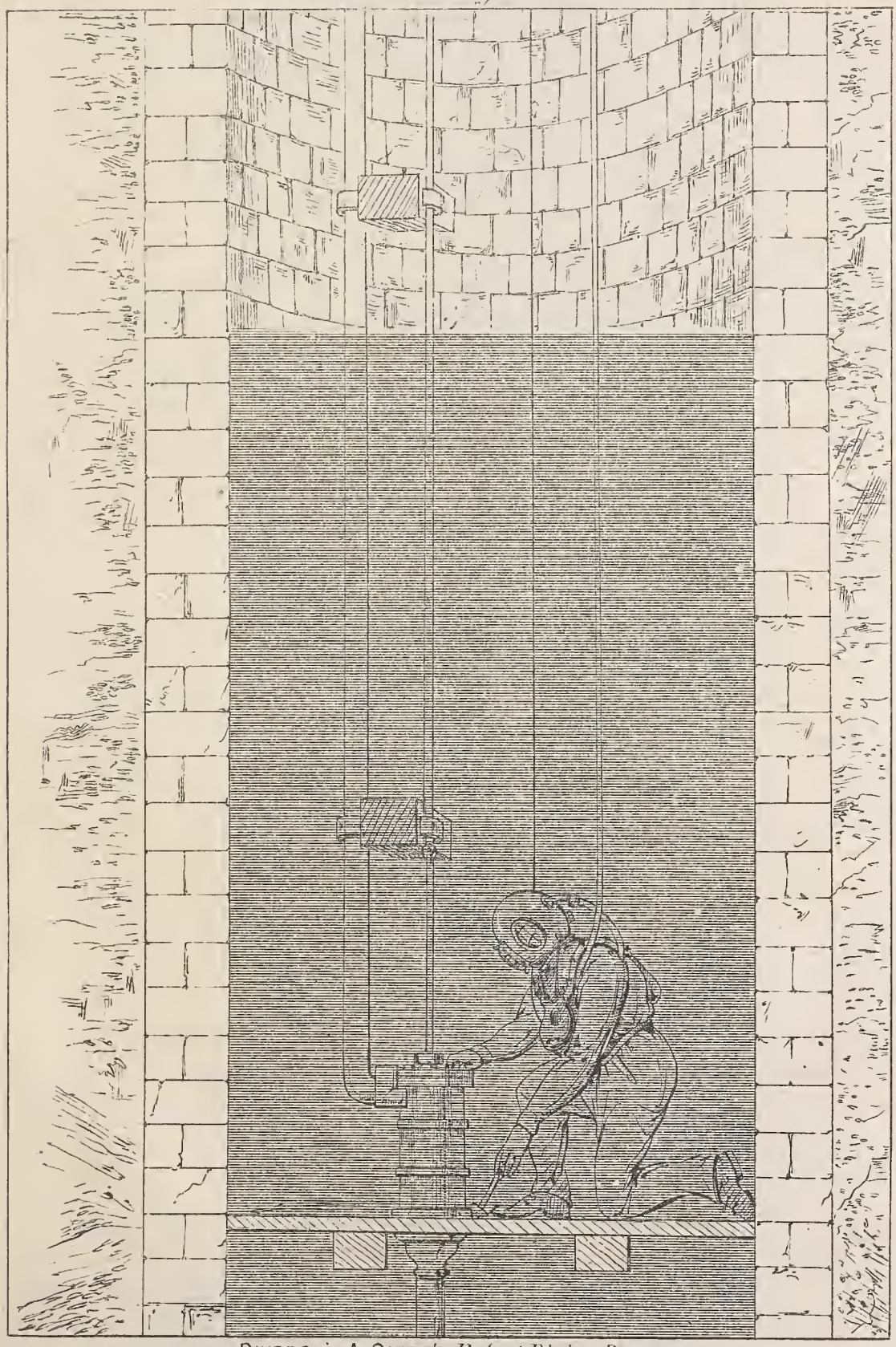
My Dear Sir,—In reply to your favour of the 10th inst., I have great pleasure in stating that, having used your Diving Apparatus (the one I purchased new of you some time since) in various forms, but kept more especially for well-work, in repairing of deep well pumps, cutting out girders, &c., when submerged with water, I have found it to answer every expectation; in fact, several instances I could mention where the works would have had to be abandoned if not for the assistance of your apparatus.

Faithfully yours,

Thomas Tilley, *Artesian Well Engineer.*

SIEBE & CORMAN,

Submarine Engineers.



DIVERS, *in* A. SIEBE'S, *Patent Diving Dress.*

REPAIRING WELL PUMPS WHEN OVERFLOWN WITH WATER.

5, DENMARK ST. SOHO, LONDON.

SIEBE & GORMAN,

Submarine Engineers,

P. HARRIS, LITH. WORBOYES, IMP.

DIVERS, *in* A. SIEBE'S, *Patent Diving Dress,*

SPONGE AND PEARL FISHING.

5, DENMARK ST. SOHO, LONDON.

TESTIMONIAL.

MESSRS. SIEBE. SYRA, *Oct.* 27*th*, 1869.

GENTLEMEN,—According to your desire I beg to inform you that I am very much pleased with the Diving Apparatus you sent me out here; in fact, they are the best we have for the sponge fishery, and I believe the only one that has not had any accident. Our divers have descended with it to the astonishing depth of 175 feet.

I remain, Gentlemen, yours obediently,

JEAN MAILI.

EXTRACTS.

"*Standard*," *December* 16*th*, 1867.

THE HURRICANE AT ST. THOMAS.—By the latest intelligence we learn that the divers were recovering the bodies and cargoes from the various ships sunk in the harbour. Captain Vesey, R.N., her Majesty's ship Doris, has kindly lent the patent Diving Apparatus, from the dockyard at Antigua, supplied by Mr. Siebe, the Admiralty having now an apparatus at each of the foreign stations. The West India and Pacific Steam Ship Company have taken immediate steps for the recovery of the Columbian, sunk in the harbour, with £200,000 of cargo, their steamer Derwent having sailed from Liverpool with several sets of Mr. Siebe's Diving Apparatus and experienced divers; also powerful steam pumps, and tackle for raising the ship.

Extract from the Journal of the Royal United Service Institution, Vol. XIII.
Colonel Gowen's Paper on Ship Raising in the Harbour of Sevastopol.

CAPTAIN HORTON, R.N.—Would you be kind enough to describe the Diving Apparatus you used?

COLONEL GOWEN—I used several systems of Diving Apparatus. I used a Diving Apparatus that was constructed by Messrs. Siebe. I found that which was constructed by Messrs. Siebe far superior to the others.

"*Shipping Gazette*," *November*, 1863.

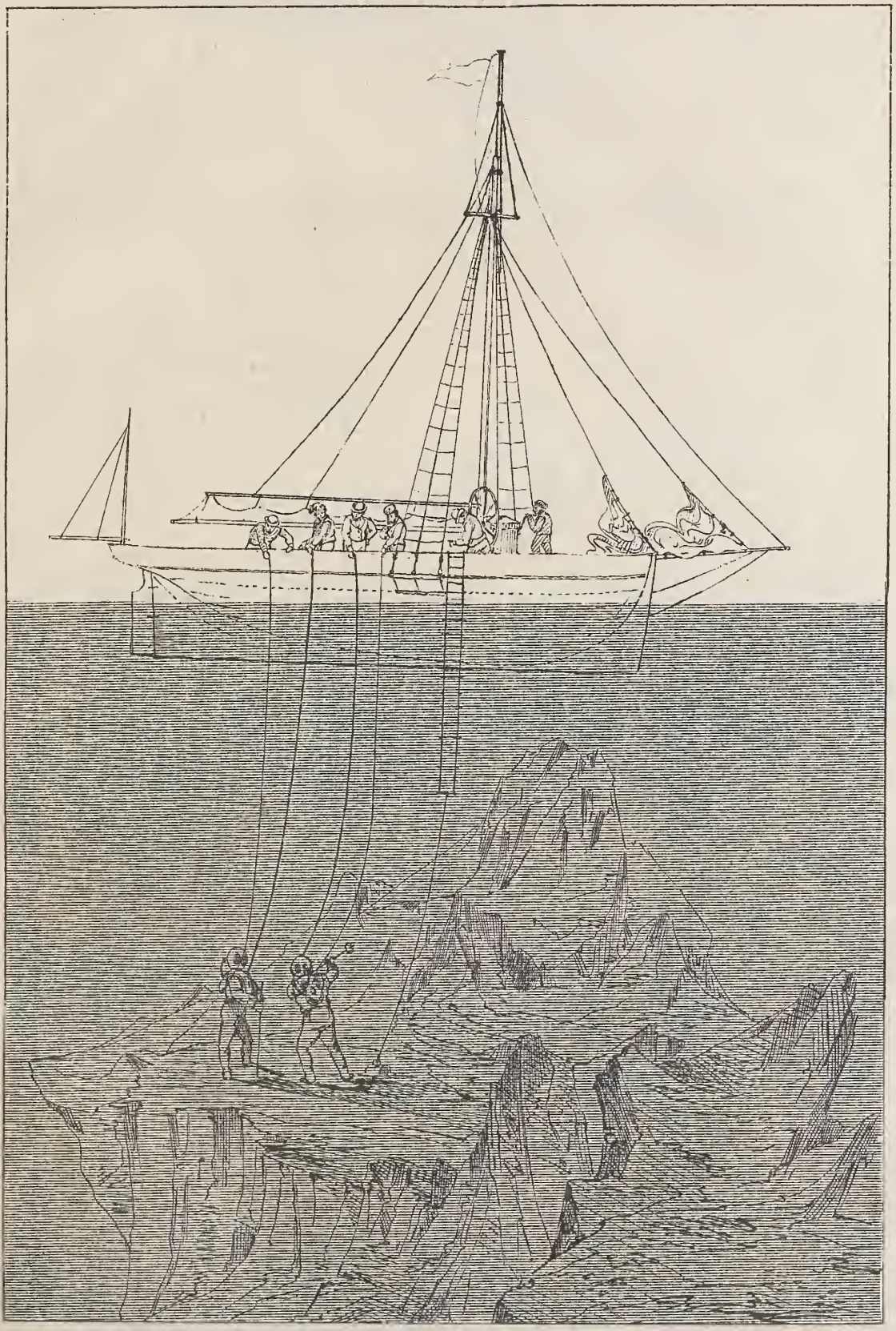
THE ACCIDENT TO THE AFRICA.—By the last mail from America we learn that the divers equipped with the Diving Dress manufactured by Mr. Siebe, London, contractor to the Admiralty, had arrived from Halifax for the purpose of patching the break in the bows. The Diving Apparatus is daily becoming of more value, not only for the recovery of sunken property, but also to the engineering world. It was by this means the Great Eastern was repaired and enabled to return to this port.

"*Times*," *September* 21*st*, 1864.

DIVING OPERATIONS.—The Matilda, a twin screw steamer, built for the blockade service, and fitted with costly engines, was wrecked last spring on her trial trip near Lundy Island. Mr. M'Duff, of Portsmouth, with Messrs. Palmer and Hicks, in their vessel the War Hawk, have recovered most of the valuable property on board. M'Duff, equipped in Mr. Siebe's Diving Apparatus, has taken her engines to pieces and sent them up. He has worked six hours a day, unscrewing bolts, &c., as if he were in a factory on shore, instead of being 42 feet under water, and exposed to a ground swell setting in from the Channel.

SIEBE & GORMAN,

Submarine Engineers.



DIVERS, *in* A. SIEBE'S, *Patent Diving Dress.*
BORING ROCK FOR BLASTING,

5, DENMARK ST. SOHO, LONDON.

A. SIEBE'S DIVING APPARATUS.

In all ages one of man's fondest dreams has been the desire to explore the hidden chambers of the deep, and to recover the countless treasures lying in its bosom, and yet even up to the present time we are but little acquainted with the vast expanse that covers the better part of our globe. From the earliest ages attempts were made to overcome, and, if possible, obtain, a hasty glimpse of the dark recesses of the ocean. The art of unassisted diving under the water is found to be limited by our natural constitution; it had not, therefore, made much progress, but curiosity and the desire of riches had so strongly exerted the inventive faculties, that from the simple naked pearl-diver we gradually came to the elaborate Diving Apparatus of the present time.

To trace the history of diving through all its different phases, would, like most other useful arts which have been brought to perfection, be an endless and difficult task. Friar Bacon, who flourished about the middle of the thirteenth century, is considered by some to be the inventor of the diving-bell. Be that as it may, the first authentic records describe it as a kind of inverted kettle, placed over the diver's head, which, with little change, grew in dimensions until it assumed the huge form of the diving-bell which Dr. Halley, early in the eighteenth century, was the first to bring into practical use. His bell was of wood, and of a truncate cone form, covered with lead and weighted so as to sink perpendicularly. Fresh air was supplied from a cask with a hole open at bottom, so that the water entered as it was sunk, and compressed the air into the upper part, to which a pipe was attached leading into the bell. As one cask was emptied another was let down. In 1721 he made further improvements, which were followed by those of Mr. Thiewald and Mr. Spalding. About the same time one John Lethbridge constructed an apparatus, which, although of little utility, may be considered the first diving-dress. It is described in the *Gentleman's Magazine*, October, 1749, as a cask, 6 ft. long, with two holes for the arms and a glass to see through. The operator had to lie on his breast to work, and be pulled up to the surface to be supplied with fresh air. In 1778 Benjamin Martin gave a description of a diving-dress, made of strong leather, to fit the body, with a glass window in front; but the diver's stay under water must necessarily have been very short. We find attributed to Kleingart, of Breslau, the most important improvement of last century, which consisted in the diver carrying a vessel of compressed air on his back. Thus stood diving at the close of last century and the commencement of the present, owing to the ignorance of the true principles of pneumatics and hydrostatics.

It was not until 1829 that any further improvement was made, when Mr. A. Siebe invented the first diving equipment, in which the operator received an abundant supply of fresh air from above, through an indiarubber tube by aid of a powerful pump. The dress consisted of a copper helmet or head-piece with glasses, an indiarubber jacket attached reaching below the waist, also a dress of similar material covering the legs and body. It was in this equipment that the Messrs. C. and J. Deane, who we must mention as the first successful subaqueous operators, recovered

many guns and much other valuable property from the wrecks of the Royal George, Boyne, Mary Rose, &c., and diving became a remunerative speculation. From the continued success of this invention several imitators soon entered into competition, but no notable improvements can be recorded until 1837, when Mr. Siebe, impressed with the possibility of water flowing under the jacket into the dress in the event of an accident to the air pump or pipe, or by the diver falling, invented the close helmet, which is hermetically fastened to the indiarubber dress, which encompasses the whole body and consequently prevents any possibility of water entering. By this arrangement the most inexperienced person can descend in any reasonable depth of water with as much safety as the most expert diver. From this date diving assumed a new aspect; landsmen found no difficulty in it, and it became a part of the study of military men, who ultimately carried on diving operations with the greatest success. The following and succeeding years Mr. Siebe further improved his invention by the expanding cup, piston, and water cistern round the cylinders, which insured a larger supply of fresh pure air and at a higher pressure: the segmental screw to remove the head-piece of the helmet in one-eighth of a turn; safety-valve to entry-air tube; self-acting exit-air valve and several others—the utility of which is undoubted, and acknowledged by all other diving apparatus manufacturers, in so far as each has not only copied the principle, but in many instances the exact model. The application of a pressure gauge to the pump, which not only indicates its efficiency but also the depth in feet at which the diver is engaged at work, is the latest improvement, and apparently leaves room for little other.

General Sir Charles Pasley, C.B., stated before the Council and members of the Institution of Civil Engineers, March 18, 1856, "As soon as I saw Siebe's Diving Apparatus, I considered it the safest and most convenient, and afterwards never ordered any other;" he further added, "that during the diving operations on the Royal George, a comparative trial of water-tight dresses was made, and Corporal Harris was equipped in Siebe's dress, in which he went down, plunging head foremost from the deck of a lighter, placed a charge on the wreck in readiness for the voltaic battery, and came up again before the other military diver who was to go down could be got ready." During the summer months, from 1841 to 1845, inclusive, four, and sometimes five, divers were daily employed in removing the wrecks of the Royal George and Edgar, under the able direction of General Sir Charles Pasley, and such confidence did the men acquire, that two of them had an encounter, at a depth of upwards of 100 ft., in which one was severely injured.

The divers, under the superintendence of Captain Martin, who used Siebe's Diving Apparatus, recovered, during the most boisterous weather, from the ill-fated vessel Royal Charter, all the articles of value, including the bullion chest, which was buried in the hull of the wreck.

Besides the recovery of sunken property, these machines are most useful for all subaqueous building purposes. A remarkable instance of their value was demonstrated at the siege of Sebastopol, where Her Majesty's ship Agamemnon, while under fire from the forts, was struck below water-line, but, nothing daunted, having one of Siebe's Apparatuses on board, the carpenter was sent down to examine the damage, and found she had been struck by a rocket; with little delay he made good the injury, thus probably saving the vessel going down.

Its utility was further demonstrated in its employment for cleaning the bottom of the iron steamship Great Eastern at Sheerness prior to her departure to lay the submarine cables in the India Seas.

Mr. Siebe has now manufactured upwards of 1,000 Apparatuses, extending over a period of forty years. Not one death in any way connected with his Apparatus is recorded.

SIEBE & GORMAN'S

Information and Instruction for Divers.

DIVERS at the depth of 32 feet under water have upon the surface of their whole body a more than ordinary pressure of 20,000 lbs. weight, yet when we consider the uniformity of that pressure, and its equability, which causes no dislocation of the parts, all the external being equally affected with it, and being internally supported by the air and other elastic fluids, which constantly endeavour the more to expand themselves as they are compressed—if we also consider the firm texture of the membranes and other solid parts of the human body, and the incredible force they are able to bear, as has been demonstrated by experiments—we shall not much wonder that Divers complain of no sensible pain, though they be pressed with so great a weight of water, besides the ordinary pressure of the air, which our bodies are continually exposed to, and which is equal to a depth of 32 feet of water, or 20,000 lbs., so that the whole pressure to which a Diver is exposed at 32 feet of water is 40,000 lbs., and in ratio as he descends.

Pressure on Divers.

Divers feel no sensible pain.

The following Table represents the pressure in lbs. on the square inch at a given depth of water:—

Table of depths and pressure.

20 ft.	8½ lbs.	90 ft.	39 lbs.
30 „	12¾ „	100 „	43½ „
40 „	17¼ „	110 „	47¾ „
50 „	21¾ „	120 „	52¼ „
60 „	26¼ „	130 „	56½ „
70 „	30½ „	140 „	60¾ „
80 „	34¾ „	150 „	65¼ „

As to the effect of compressed air upon the lungs, and the general construction of the human body, scientific men vary, and as we have no data from which we could form actual conclusions, we can only arrive at a result by the effects produced upon Divers that have come under our notice. The first time a man descends under water he is ordinarily suffering from inherent nervousness, occasioned by the fact of undertaking a thing that has hitherto been unknown to him, consequently there is an increased pulsation and peculiar gasping for breath; and it happens in some cases to be so strong that it would be unadvisable whilst in that condition to allow them to descend, but rather by making them acquainted with the working of the apparatus, and the example of teaching others to descend, it will gradually remove the nervous weakness which attends many constitutions. When the nervousness is overcome it would be advisable that they should descend slowly, swallowing their saliva, and not demanding too much air, resting at times to recover their equilibrium; and if the pressure should cause too great a pain in the head, by gently ascending a few feet it will gradually remove it, and the descent can be continued.

Effect of compressed air on the lungs.

On nervousness before diving.

Rules for descending

Effect of compressed air.

Remarking the effects of compressed air on the lungs, Mr. Brunel, when inspecting an accident over the Thames Tunnel, the bell not being able to enter the hole, he took a rope from one of the attendants and plunged into it, remaining about two minutes, much above man's natural powers. The compressed air in bell being about 32 lbs. on the square inch, it is reasonable to suppose that the lungs act as air-sponges, and were saturated with this condensed vital element as he left the bell. Would it not, therefore, take more time than in ordinary circumstances to exhaust this double provision of breath?

Rules for ascending.

The rule as to coming up depends very much upon the constitution of the Diver. A man at all sanguineous should ascend rather slowly; the brain being suddenly relieved from the pressure causes a sudden rush of blood to the head, and it may cause serious and unpleasant consequences. We should advise a Diver to ascend at a rate of not more than 2 feet every second—that is, for a strong constituted man. Nor should a Diver, for at least two hours before commencing operations, take any food. If any kind of refreshments be required, a biscuit with a small quantity of drink, or anything that will not excite the digestion, may be taken during the operations.

Not to take food before diving.

Diving as a healthy exercise.

We have no doubt, from our long-continued experience, of affirming that, as a rule, diving is not injurious when conducted under ordinary precautions, and instances have come to our knowledge where Divers now living and passing the ordinary span of life, who in their youth were sickly and suffering from weakness of the lungs, are now hale and strong, which can only be accounted for that from breathing compressed air necessitates a slower action of the lungs, absorbing a greater amount of oxygen into the tissue of the lungs, and a lesser expansion of the chest, and by the continual practice it becomes a habit.

Reasons why compressed air is healthy.

At the French Academy a paper was read by Dr. Gent, showing that compressed air is an excellent remedy for asthma and emphysema, or swellings of the integuments. It is, he said, both a sedative of circulation and breathing, and a tonic for the mucous membrane of the bronchiæ; so that it is useful in all disorders of the respiratory organs, such as bronchitis, catarrh, whooping-cough, &c. It moreover excites digestion, owing to the greater quantity of oxygen it carries into the blood.

We will now proceed with the Instructions for the Dressing of Diver and the Management of the Apparatus.

Management of air-pump.

Previous to the Diver being dressed, place the fly on crank shaft, and fix the handles at right angles, oil the pistons with olive or neatsfoot oil, and also the bearings and other working parts; let the pump be worked for a few minutes; also pour some water into the cistern to keep the cylinders cool, to prevent the air being heated and thus becoming rarefied. The piping should be laid on the deck or place from whence the descent is to be made, in a serpentine form, so that the pipe does not kink. Remove the nut on air-nozzle, and connect the air-pipe. The attendant should place his finger over the joint at the end of air-pipe, and let the pump work so that he can test the working of the air-pump's valves, and blow out any dust that may be in the pipes. If the water in the cistern becomes heated it should be renewed.

Dressing the Diver.

Put on the guernsey frock, a pair of drawers and stockings according to the temperature of the water; place helmet cushion on shoulders, and tie the tapes under the armpits. Then put on indiarubber dress, tie the inside collar-piece round neck, and round each wrist place one or more vulcanised indiarubber rings. A piece of linen should be placed between the flesh and dress; the cuff-expanders should be used, so that the Diver can pass his hand; then put on helmet collar, place the vulcanised collar over the screws, put on the metal plates, and screw the dress between moderately tight with the wing nuts; be

particular that the four nuts at joints are screwed up at the last. To keep the dress from chafing put on large overall stockings and canvas overall dress, then the boots with lead soles, and the leather belt with pipe-holder and knife. The attendant should blow through the outlet valve of the helmet; he can do so by placing his head in the interior and placing his mouth to the hole where the air escapes; blow strongly; if in proper working order the valve will vibrate.

Connect air-pipe to inlet valve; previous to doing so pass it through the pipe-holder on belt, leading it under the "left arm" of Diver, the signal line to be fastened round the body, and to pass up the front of the right shoulder; the head-piece (without the front glass) can now be screwed on, which is done by one-eighth of a turn. Next attach the lead weights one behind and one before; the lines of the back weight pass over the loops on head-piece; the small line should be fastened to the lower corner of weights and round the waist with a slip knot in front. The Diver now being dressed the air-pump must be set in motion; when all is ready for the Diver to descend, screw in the front glass.

Diver's signals.

Life Line.	1. Pull . . .	All right.
,,	2. ,, . . .	According to Diver's instructions.
,,	3. ,, . . .	Do. Do.
,,	4. ,, . . .	Coming up.
Air Pipe.	1. Pull . . .	Sufficient air.
,,	2. ,, . . .	More air (pump faster).
,,	3. ,, . . .	According to Diver's instructions.
,,	4. ,, . . .	Haul up Diver.

Speaking apparatus.

To communicate with the Diver when underneath the water by word of mouth, we have made several experiments with very satisfactory results, and hope soon to so far perfect it as to bring it into continual practice.

Ladders for diving.

Divers' ladders are generally made of inch rope with ash rounds 22 inches long and weighted at the end. Some divers have the ladder only 20 feet long, to the last round a rope with a weight attached, which rests on the bottom; by that means they descend.

Instruction to Divers when underneath.

All now being ready let the Diver descend, and when he reaches the bottom, before he leaves the ladder, he must make fast a small leading line to the ladder. The line should be coiled in the hand with a loop round the wrist, and as he leaves the ladder he lets the rope gradually uncoil, so that if he is any distance off he can find his way back to the ladder if he wants to ascend; but if by accident he loses the line and is unable to find the ladder, he should make the signal to haul him up. In extreme cases the weights may be thrown off—that is, if he finds himself in any danger and he wishes to rise directly to the surface of the water; but this expedient we should recommend to be seldom resorted to, as the signal for hauling up can always be given, and with presence of mind many difficulties can be overcome when hurry and excitement may cause the loss of the Diver's life.

The Diver should seldom go forward; he must generally go backwards; and if he meets with anything he must turn round and feel, particularly in the dark; but be careful to return the same way, otherwise he crosses the pipe and line; this precaution is very necessary. If entangled in the rigging make use of the knife at side to clear himself away.

Some Divers require more weight.

As some men require more weight to sink them than others, we would recommend them to make a shot belt to buckle round the waist; it may be made any weight the Diver may think necessary.

Instruction to attendants.

On the deck or place from whence the Diver descends two careful, confidential persons must attend the signal line and air-pipe; they must attend them with the same vigilance as a nurse would attend to a child, and keep them always moderately tight. If they should feel any irregular jerks which may be occasioned by falls or otherwise, they must haul him up immediately. The attendants on deck must from time to time give the signal that all is right, and if the Diver does not return the signal he must be immediately hauled up. Be particular that no conversation whatever is held with the attendants of the Diver when below, as it may take off their attention from the signal or any circumstances that may occur.

Observation on air-pumps.

If the plungers of the air-pump or the other motions get slack, they must be screwed up with the spanners sent for that purpose, when the plungers will swell out a little; great care to be taken that they are put in the same way as they are taken out, and all other parts of engine put together according to the marks. Always use olive-oil for the air-pumps; if not to be got, use well-cleaned neatsfoot oil. When done working, and the engine is to be put by some time or lifted about, unscrew the plug at the lower edge of the back of the box and draw out the water, to prevent it washing over into the box or cylinders, or splashing engine, or corroding the cistern if left standing. If the air-pump has been left standing by for any length of time, pour some warm water into the cistern, as it will warm the cylinders and soften the oil round the pistons, and the pump will work much easier.

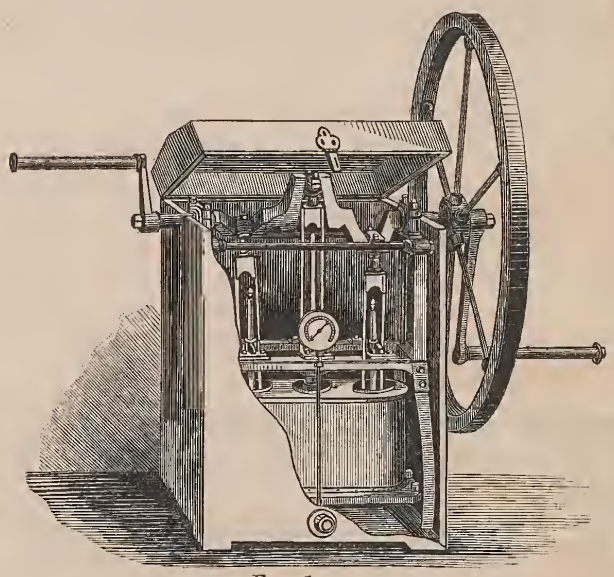


Fig. 1.

Examining air-pump valves.

To examine piston valves, withdraw piston from cylinder. When the valve can be unscrewed, to examine cylinder bottom valves, lean the chest back and unscrew iron plate on bottom of chest, and then unscrew the valve bonnets; this arrangement avoids the trouble of removing engine from chest.

Connecting pipes.

Be careful that the leather washers are between the gun-metal joints, so that the air may not escape, also that the joints are screwed together moderately tight.

Repairing indiarubber dress.

Should the waterproof dress, from constant use or accident, get leaky, it is easily repaired by laying two or three coats of varnish on each side of the seam, rubbing it with the finger as much as possible into the perforations made by the needle, allowing each coat to dry before the next is laid on; the sides of the seam may then be laid down, and two or three coats applied in the same manner to the channel of the seam, when the prepared strapping (which should have an extra coat laid on and dried) may be immediately applied, and well pressed down with the hand. Superfluous varnish may be removed with a piece of indiarubber, but it is better to lay it on the proper width, so as not to require cleaning off, as too much friction sometimes does injury. Beginners should prove their seams by tapping them, when moistened externally with water.

Indiarubber diving dresses should never be packed away in a wet or damp state; they must be thoroughly dried both in and outside before so doing, otherwise they will mildew, and become so rotten as to be of very little service afterwards. Management of the indiarubber dresses.

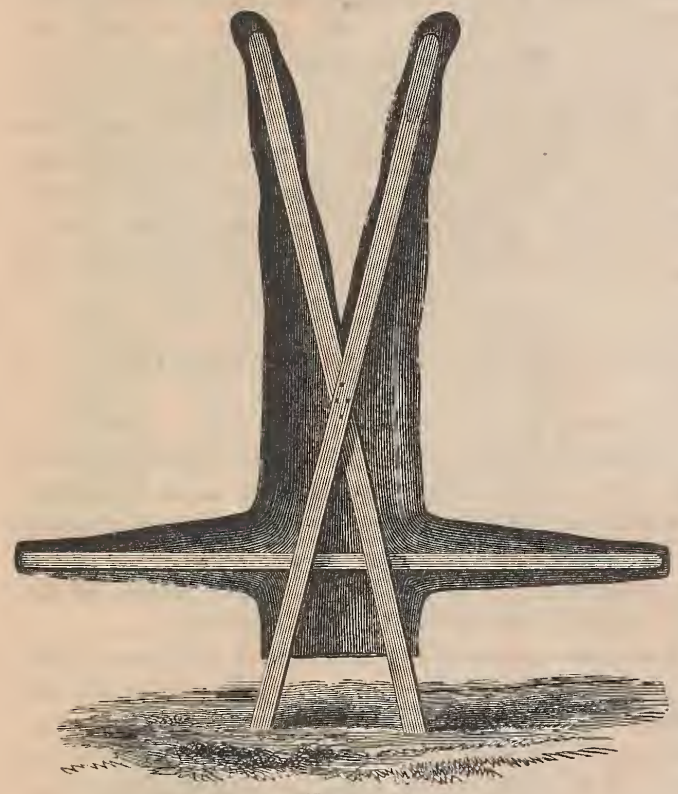


Fig. 2.

Fig. 2 represents an easy and efficient mode of drying the diving dresses.

Take two pieces of wood about 8 feet long, nail or screw them together as shown, place them inside the dress, and pass another piece through the arms to keep distended; the dress can then be leant against a wall until it is dry.

In case the Diver urinates in the dress it should be turned inside out and washed with clean water, and then allowed to dry.

If the above directions are properly attended to, the diving dresses will last much longer.

The indiarubber pipes should also be thoroughly dried before packing away. Management of air-pipe.

Should the dress and pipes be lying by for any length of time, and become hard, place them in a gentle heat, when they will become quite soft.

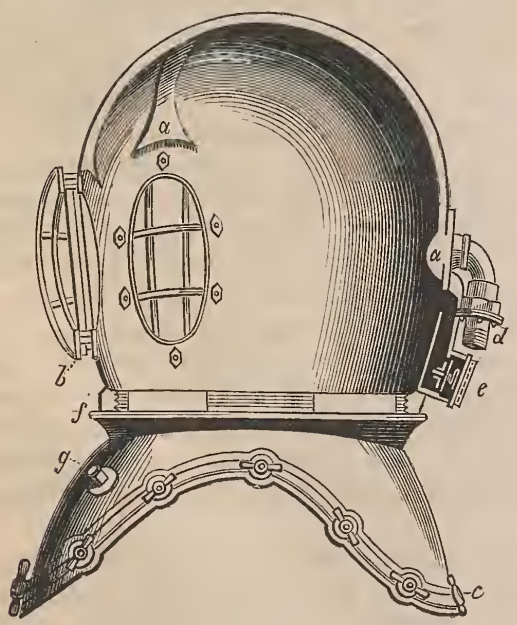


Fig. 3.

Siebe's Helmet, as represented Fig. 3, consists of a front glass (*b*) which can be unscrewed to enable the Diver to take refreshments or give orders without removing any other portion of the dress. The dress is fastened to the helmet by means of the flanges (*c*), pressed together with screws and wing-nuts; the air enters at the back by the valve (*d*) screwed on the elbow; this allows the air to enter the helmet, but prevents its return. If the pipe should burst, the Diver has plenty of time to come to the surface. The outlet valve (*e*) allows the foul air to escape, Description of helmet.

and prevents the entrance of the water. The valve-spindle is immediately closed on the least cessation of the supply of the air, by means of a spiral spring, as well as by the pressure of the water; this valve being slightly loaded prevents the pressure of the water acting on the body of the Diver, in consequence of the internal pressure being greater than the external. The air after entering by the valve (*d*) is conducted by tubes (*a*) to the Diver's face, so that he at once inhales the fresh air, and at the same time the breath is prevented from condensing on the glasses. (*f*) is the segmental screw, by means of which the head of the helmet can be removed by an eighth of a turn. The head weights are attached to the studs (*d*) by means of sliding clips. The ropes of the back weight are passed over two hooks on the head of the helmet, thus entirely preventing the head becoming unscrewed by accident; also regulating valve when ordered.

ON THE IGNITION OF GUNPOWDER BY ELECTRICITY.

Gunpowder may be exploded by electricity—

1st. By the heating effect of a current of electricity, when circulating through a very thin wire, offering considerable resistance to the current, the thin wire being in contact with the powder, and bridging over a break in a thick wire composing the electrical circuit.

2nd. By the electric spark or discharge across a break in an electrical circuit taking place through a substance which offers a very great resistance to the passage of the electricity, and which is sufficiently heated by the discharge to ignite gunpowder.

In both cases the work done in overcoming resistance is exhibited in the form of heat, but in the first case the resistance to be overcome in the fuse is comparatively small; the other resistances in the circuit should therefore be proportionally small, and the electro-motive force may also be inconsiderable. These are conditions corresponding with the effects produced by voltaic batteries of few cells, having small internal resistance and short metallic circuits of small resistance, but not necessarily well insulated.

In the second case the resistance to be overcome in the fuse is comparatively great; the other resistances in the circuit and the electro-motive force should be in proportion. These conditions correspond with the effect produced by a larger number of cells of a voltaic battery having considerable internal resistance, or by induction currents from permanent or electro magnets and long circuits of thin well-insulated wire.

Siebe's Voltaic Battery.

Of the many forms of Voltaic Battery for submarine puproses, that constructed by Mr. Siebe is the most portable and the most simple of manipulation; it can be used by any person not understanding the least about electricity; being very compact it is easily removed from place to place, and the most suitable for using on vessels at sea, as it consists of nothing that is breakable; this battery, as represented Fig. 4, is composed of ten elements, each element being composed of one zinc plate amalgamated with mercury and two of iron; the top connections are copper slips; each one of the plates fits in a groove, and any one of them can be removed without the least trouble; the whole of the ten elements are fitted on a framewith an apparatus to allow it being lowered into a trough containing the diluted acid; when not in use this is a great advantage, as there is no unnecessary loss from the consumption of the metal, whilst the acid retains its full power ready for use.

Directions for using the Voltaic Battery.

Take about 8 parts fresh water to 1 part sulphuric acid (or oil of vitriol) by measure, mix them together in a glass or stone jar, or vessel from which it may be easily poured into the trough of the battery, through the copper funnel at its end, until the solution

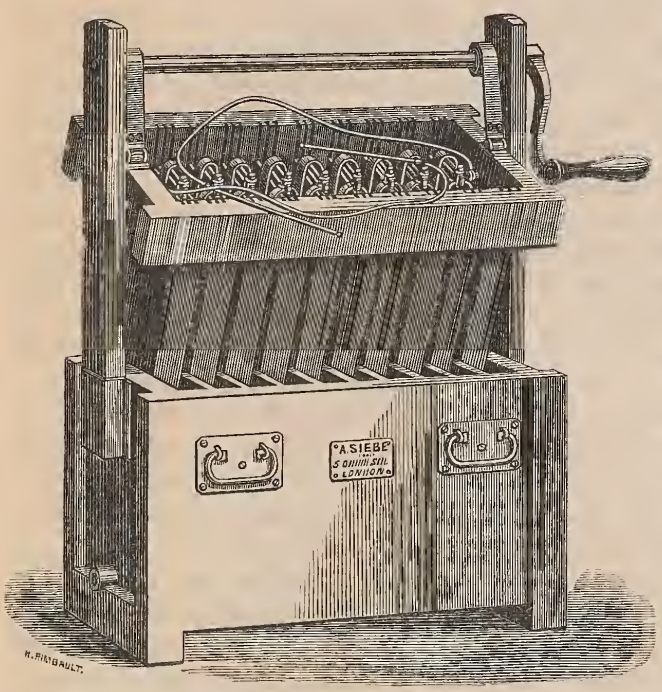


Fig. 4.

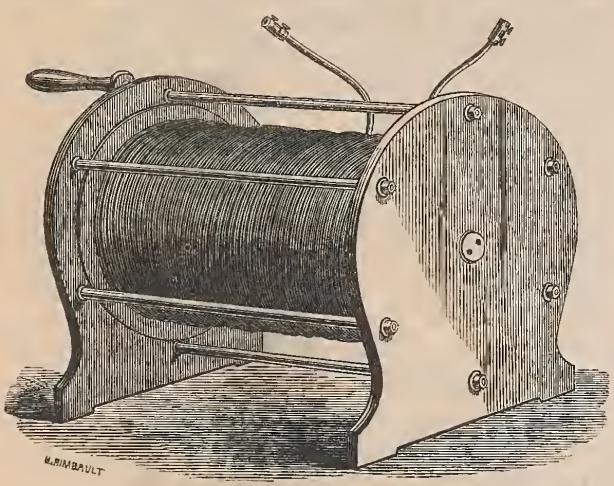


Fig. 5.

rises as high as the bottom of the funnel; the upper frame with the plates must be kept wound up out of the solution until the charge is ready for firing; when the plates are lowered into the solution the ends of the two touch wires must be held together for 15 seconds, to get the battery in proper action, after which put the two touch wires each into one of the copper holes at one end of the reel, as represented Fig. 5, and the explosion will take place.

When the charge has exploded wind out the plates directly, and if the battery is not going to be used again the same day, draw off the solution through the plug-hole at one end of the battery trough, and refill it with water and lower the plates into it for half an hour, to wash off the acid, after which draw off the water as dry as possible, and it may be laid by without injury.

The solution may be bottled, and with the addition of a little more sulphuric acid, may be used several times.

Standard of force of current, or quantities of electricity circulated.

The measure of the force of the current or quantity of electricity circulated at each instant of time which has been found most suitable to the first application for the ignition of gunpowder is the fusion of a piece of platina wire of a definite weight and length, such as is used in the fuse to ignite gunpowder. The wire generally used weighs 1·95 grains per yard, and is $\frac{3}{10}$ of an inch long. This is a measure which can always be produced with a fair degree of accuracy, although the conducting powers of different samples of platinum are not exactly equal. The platinum wire should not be thicker than the above, or the battery must be increased in size to produce corresponding results, but if somewhat thinner, the same batteries will heat a large number of wires, or the same number of wires with a greater length of conducting wire included in the circuit. There will, however, be greater risk of fracture if the wire is much thinner.

Weight and length of platinum wire.

Many different arrangements have been proposed for introducing the small piece of

Fuses.

Platinum wire fuses.

platinum wire safely and securely into the circuit. The platinum wire being very fragile, must be protected from injury either by a blow, or by the twisting or movement of the conducting wires to which it is attached. It must be in perfect metallic contact with the conducting wires. The conducting wires to which the platinum is attached must be firmly fixed, insulated from one another, and so arranged that they can be readily connected with the conducting wires from the battery. The following arrangement is perhaps the best which has been devised:—A small wooden box may be made of deal. A pair of gutta-percha covered wires, No. 16 gauge, freed from gutta-percha at the ends, and passed through the sides of the wood box, care being taken that they are exactly $\frac{3}{10}$ of an inch apart in the box; a piece of platinum wire is then soldered between the two wires, the cavity is filled with fine grain powder, and the lid tied down with twine. The platinum being soldered to the two wires forms the only metallic connection between these.

Method of connecting the fuse with powder under water.

Another arrangement is shown at Fig. 8, which we used with success during the submarine operations against the wreck of the Royal George. It is very simple and easily understood, but requires care in placing it in the interior of blasting charge. When charges are placed under water they are generally kept dry by being inclosed in tin or iron cases, as shown at Fig. 7. India-rubber cloth bag, or bags made of canvas, and rendered waterproof by the ordinary composition of pitch 1 lb., tallow 2 oz., and beeswax 2 oz., have also been used with success; strong Mackintosh cloth being, however, more to be depended on than the other when the pressure of water is considerable. For very large charges under a considerable depth of water iron cases are best, tin not being strong enough to resist the pressure of the water. When bags are used, the fuse is placed inside, and the wires may be securely fastened in the neck of the bag without difficulty; but whenever metal is used, the priming apparatus should be inserted into a metal tube, closed at the lower end, and soldered into the case; the fuse is placed therein, and hot pitch composition poured on the top of it; by these means, should any moisture penetrate into the fuse, the powder will remain uninjured, a loading hole being left for the entrance of the powder, which must be hermetically closed by a screw cap or otherwise.

Frictional electric machine.

This machine, Fig. 6, is constructed of ebonite or hardened indiarubber, which is a more perfect insulator than glass, and possessed of remarkable hygrometric properties, resisting the deposition of moisture upon its surface even in an atmosphere saturated with vapour of water; it has also the great advantages of portability, of being always

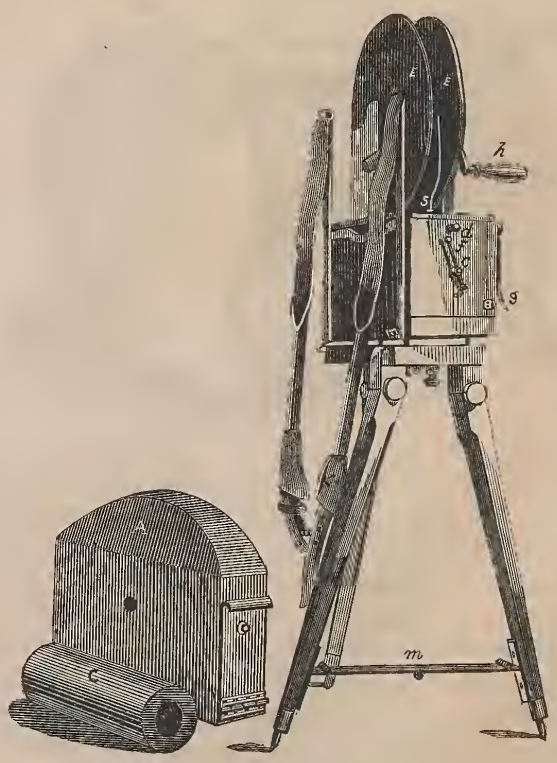


Fig. 6.

ready for use, and efficient at a great distance from the charges; if used from the land one conductor only is required. A light tripod of varnish wood forms the stand, and there are iron bars and straps, so, if necessary, it can be carried like a knapsack. To use the instrument, the knob (×), not shown, is connected with the earth or to one of the conducting wires (*f*), is drawn down to its greatest distance from (*d*); the insulated wire leading to charge is connected to (*d*). The operator steadies the instrument with his left hand, and by one foot placed upon the cross stay of the tripod; he then turns the handle 50 times rapidly with his right hand, and instantly brings that hand down on the trigger (*g*), when the condenser is discharged through the circuit and the charges are exploded. This machine should not be used without its cover, as floating particles in the air are attracted by the highly electric condition of the discs, and form an accumulation of dirt with amalgam.

Mode of using the instrument.

The discs may be cleared when necessary by the application of a little paraffin oil or turpentine.

It is necessary that the trigger be touched immediately on ceasing turning the handle, or there will be a loss of electricity and a corresponding chance of failure.

Precautions to be observed.

The tension of the electricity developed in this instrument is so high, that not only must the insulation of the conductors be perfect, but induction must also be guarded against, and precautions must be used to avoid the possibility of a spark passing through the air to the body of the operator or any other conductor. Knowing the greatest distance at which a spark will pass by means of the test rod (*f*), this latter danger is easily guarded against. The evil effects of induction are somewhat more difficult to be guarded against.

A conductor composed of three strands of thin copper wire (No. 24 gauge) twice covered with indiarubber and protected with plaited hemp and tarred, is preferable. The length of the main conductor is comparatively immaterial, provided the insulation is good, and induction be guarded against.

Conducting wires for electrical machine.

The charges to be exploded by frictional electricity must be connected in continuous circuit; as many as 50 fusees can be exploded simultaneously in this way, if they are fresh and good, but it is not considered advisable to connect more than 30 in one circuit.

Mode of arranging circuits.

INSTRUCTIONS FOR PREPARING AND LAYING SUBMARINE CHARGES.

Previous to preparing the voltaic, frictional, or any other kind of battery that may be used, it is necessary that the charges should be made and laid down in the places where they are required, which is done in the following manner:—For small charges we find a tin canister of oil-can shape answer the best, similar to that represented Fig. 7, and for a large charge a barrel, as also shown Fig. 7; in making the charges take one of the wooden boxes, as represented Fig. 8, in which the two pieces of copper wire are connected with the platina, and fill it loosely with meal powder, or some gunpowder which has been

crushed under a wood roller (these instructions are not required with Abel's fusees, they being perfect in themselves). When that has been done put the wood box, which is now

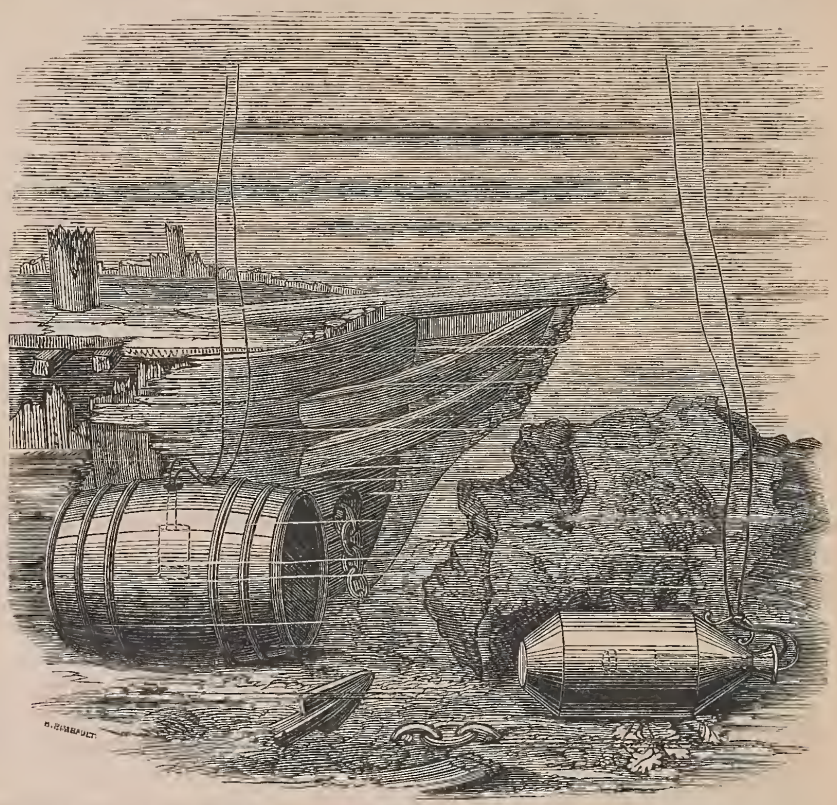


Fig. 7.—Illustration of the Placing of Charge in Blowing up Wreck and Removing Obstructions Under Water.

the igniting charge, into the middle of the canister or barrel of gunpowder, and the two wires of the igniting charge must be passed, by two separate holes, through the cork or bung of the charge, and then smear it over with a mixture of resin and beeswax melted

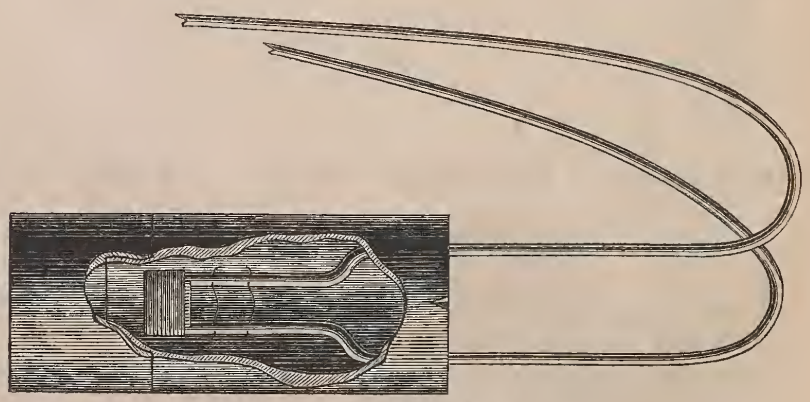


Fig. 8.—A. Siebe's Improved Platina Charge.

together, to keep it watertight; then connect the two wires of the igniting charge with the two on the reel by the means of a binding screw, or flattened, and then lashed together

with copper binding wire; then wrap all the bare wires in silk, cotton, or indiarubber strips (but be sure to scrape clean the ends of the wire where they join). After they are wrapped over smear them over with some of the mixture above-mentioned, or any varnish that will keep it watertight. For greater security that the wires should not draw out the charge, bend them over, as they are represented Fig. 7, and lash them to the handle of the canister or barrel. After all this has been done fasten a rope to the barrel or canister and lower it down to the place where it is required, at the same time the conducting wire must be unwound as the lowering takes place. After the charge is down, and everything is ready and the Diver has come up, if using the voltaic battery, lower the plates into the solution and put the two touch wires or poles of the battery in contact with the two trumpet-mouth copper holes at the end of the reel, and, if all is right, the charge will explode immediately. If using the frictional machine, it is necessary to give not more than 50 turns before completing the circuit.

Precautions to be observed.

Among other observations we particularly recommend that all connections or contacts be well cleaned before being put together or used, not with oil, but with a piece of dry sand or emery paper; also, before putting the gunpowder into the canister or barrel, stop up the mouth, and lower it to the bottom of the sea, to ascertain if it is watertight, as the gunpowder gets spoiled if they are leaky. Similar instructions must be followed in using compressed gun-cotton or other explosive substances, and in every case perfect insulation must be insured.

Fuses for the Frictional Machine.

This fuse is thus described by Mr. Abel to consist of—

"*a*. A head for receiving the wires which connect the fuse with the frictional machine and the earth.

"*b*. Of the insulated wires, with the terminals of which the priming material is in close contact.

"*c*. Of a small cartridge, or charge of powder, inclosing the terminals, upon which the sensitive composition rests."

The fuse-head, which is of boxwood, contains three perforations. One, passing down through the centre, receives about two inches of double insulated wire (two copper wires of twenty-four gauge inclosed side by side at a distance of one-sixteenth of an inch in a coating of gutta-percha of one-eighth of an inch diameter); the other two perforations, which are parallel to each other, on each side of the central one, and at right angles to it, serve for the reception of the circuit wires. The arrangement for securing the connections of these with the insulated wire in the fusees is as follows:—The piece of double covered wire above referred to is originally of a sufficient length to allow of the gutta-percha being removed from about 1½ inch of the wires. These bare ends of the fine wires, which are made to protrude from the top of the fuse-head, are then pressed in the slight grooves in the wood provided for their protection, and the extremity of each is passed into one of the horizontal perforations in the head, in which position it is afterwards fixed by the introduction into the hole of a tightly-fitting piece of copper tube, so that the wire is firmly wedged between the wood and the exterior of the tube, and is thus at the same time brought into close contact with a comparatively large surface of metal. It will be seen that it is only necessary to fix one of the circuit-wires into each of the tubes in the opposite sides of the fuse-head in order to insure a sufficient and perfectly distinct connection of each one of them with one of the insulated wires in the fuse. Perfect contact should be secured by a copper tack, used as a wedge.

The extremity of the double covered wire, which protrudes to a distance of about

three-fourths of an inch from the bottom of the fuse-head, is provided with a clean sectional surface by being cut with a pair of sharp scissors, care being taken that the extremities of the copper wires are not pressed into contact by this operation.

A small cap of about half-an-inch in length is then constructed of thick tinfoil or of paper, into which is dropped about one grain of the priming material, which is composed as follows :—10 parts of subphosphide of copper, 45 parts of subsulphide of copper, and 15 parts of chlorate of potassa, each reduced to a very fine powder, and the whole thoroughly incorporated in a mortar, with a little alcohol added, carefully dried and preserved in a closed vessel until required. The double wire is then inserted and pressed firmly down into the cap, so that the explosive mixture is slightly compressed and in close contact with the surface of the wire terminals.

The cap is fixed by winding a piece of twine once or twice round its upper part, tightening the ends of this and then removing it. The actual fuse is then ready for inclosure in a small charge of gunpowder. The powder is contained in a paper case tied on to the head, or in a cylinder of wood, or of sheet tin tightly fitting on the fuse-head at one end, the other, after the introduction of the powder, being closed with a plug of clay or plaster of Paris.

This fuse is adapted to the electricity obtained by friction, or to the momentary currents of induction derived from permanent magnets or electro-magnets. It can also be ignited by the direct voltaic current, about fifty Groves' cells being necessary to overcome the resistance with certainty.

BORING AND BLASTING OF ROCKS UNDER WATER.

In blasting rocks under water it depends very much on the character and formation before decided instruction can be given for its removal. If the rock is of a precipitous nature the best means are to commence drilling a row of holes parallel to the edge, and at a distance from it equal to the depth of the holes; the holes should be driven to about three feet below the required level. After blasting out these holes a fresh series must be drilled parallel to the former ones, or to the face left by the blasts, and these also blasted out a third line, and so on, progressing regularly across the rock, continually blasting it off in parallel blocks, extending downward a little below the depth required.

The advantage of this mode of operating is that it enables the blasts to act laterally, in which direction they are the most powerful, and the rock is left, after each series of blasts, with a nearly vertical side or face, in which the presence of seams can be detected, and the character of the strata observed, so that the most favourable positions for the next blasts to produce the greatest effect can be selected. Sometimes the craters, following the strata, run under or leave an overhanging face, in which case a large charge (Fig. 7) usually has the effect of throwing off the overhanging portion, and often dislodges large masses of rock.

After the rock has been blasted entirely across and to the general depth required, a careful survey must be made, and projecting points drilled through and blasted off.

Description of a Submarine Drilling Machine.

This machine consists generally of a drill, drill-stand, or guide, a clutch or hoister, and an adjustable connection with the motive power, situated on the deck of the working vessel.

The drill is a churn drill, about 16 feet in length, $1\frac{3}{4}$ diameter, and weighing about 125 lbs. It cuts by the force due to its weight, which may be made greater or less, as the rock to be drilled is softer or harder.

Description of Drill for Boring.

The drill-head, or cutter, is about 14 inches in length, and is attached to the lower end of the drill-shaft by a socket and pin. The cutting edge is made similar to the form of the letter S, as this is found to stand better and work truer than any other form. They may be made to cut any sized hole from 2 to 6 inches; a hole about $3\frac{1}{2}$ inches is generally sufficient.

The drill-stand consists of two parallel plates connected by uprights, to serve as guides to the drill-shaft, the lower plate being supported by three legs, made adjustable in length to fit the uneven surface of the rock. It is made of iron, and heavy enough to resist an ordinary current. A weight of about 850 lbs. will maintain its stability against a four-knot current. To resist stronger currents its weight must be increased, and in addition guys attached to the upper plate, and iron pins driven into holes drilled in the rock by the diver with a hand-drill may be used if necessary.

Description of Clutch on Boring Machine.

The clutch, or hoister, is a bar of iron with an oblong slot through it, through which passes the drill-shaft. When the clutch is raised the sharp bevelled edges of this slot gripe the drill-shaft and raise it. One end of the clutch is forked, to run upon a spiral guide, so as to turn the drill as it is raised. The other end is weighted, so as to bring the clutch rapidly back to its first position after its gripe upon the drill-shaft has become disengaged by a trip pin on the spiral guide, against which the fork of the clutch strikes in its ascent.

Description of Guide for regulating Hoist.

The spiral guide which regulates the turn of the drill is made adjustable in inclination, so that greater or less turn may be given for any fixed elevation or hoist. The trip pin is also made adjustable in position upon the spiral guide, so as to regulate the "hoist" or fall of the drill, to suit the degree of hardness of the rock. It is usual to give as great "hoist" as the cutting edge of the drill will stand without breaking.

Attached to the clutch is a chain which passes through a hole in the upper plate, and is attached at its upper end to a ballasted block, to the crank-pin of a steam-engine situated on the deck of the working vessel, and the other end to cleat on or upon the rail of the vessel.

To operate the Drill.

The working vessel having been moored over the rock by means of the mooring-lines attached to buoys placed about 150 feet from each quarter of the vessel, the Diver, ready dressed, descends and selects the exact position for the blast, and then signals to have the drill and stand lowered to him. This being quickly done by means of a steam derrick, he guides the drill-stand to its place, and finally fixes it in position by means of its adjustable legs. He then signals to haul up and make taut the drill-lines attached to the motive power on deck, and this being done he signals to commence drilling.

The crank-plate of the engine being thrown in gear, the engine being in motion, the end of the drill-line attached to the crank-pin is raised, which raises the ballasted block, the drill-chain, and the clutch, which latter gripes and raises the drill, turning as it rises until the forked end of the clutch strikes against the trip-pin, when the drill-chain, still hoisting the grip of the clutch, is disengaged, and the drill falls straight, cutting the rock by the force due to gravity.

The crank-plate continuing its revolution, the drill-line and chain is lowered, per-

mitting the clutch to descend to its first position, ready to gripe and raise the drill again.

The revolutions continuing, the drill is raised and let fall, making a cut at each revolution of the crank-plate, and in this manner the drilling proceeds, the drill usually making from sixty to eighty blows per minute.

As soon as the Diver sees the drill in perfect operation, he either busies himself with any other work that he may have to perform upon the bottom, or comes to the surface of the water, supporting himself upon the ladder attached to the side of the vessel for his use, and waits for some necessity of his diving again.

Sometimes the drill works uninterruptedly till the hole is drilled to the depth desired. At other times its working requires the constant attendance of the Diver, either in replacing drill-heads broken by contact with hard crystals, or in regulating the turn or "hoist" of the drill, or in clearing the holes of cuttings, or spooning out, as it is termed, or rectifying the direction of the drill by adjusting the legs or guys.

Boring Indicator.

To afford an indication above-water of the motion of the drill below, and thus to obviate the necessity of the Diver going down for this purpose, an iron rod is fitted into a square socket on the upper end of the drill-shaft, and to the upper end of this rod a wooden pole, extending above-water, is attached. This pole, being held by an attendant standing upon a movable staging rigged out from the side of the vessel, indicates clearly to him the motion of the drill, and also enables him to prevent the drill falling repeatedly into the same cut, or "bouncing back," as it is termed.

In rough weather the staging and index-pole cannot be used. At such times the motion of the drill-line is the only indication above-water of the working of the drill. Frequent descents of the Diver are then necessary. The tendency of the drill to "bounce back" is prevented by a ratchet and paul placed on the upper guide-plate, and operated by a vertical groove in the drill-shaft and a pin on the ratchet.

Working the Drill in strong currents.

It is found that the drill can be worked in a rapid current as well as in slack water. This will enable the operation of drilling and blasting to be conducted in an extremely rapid tidal current by a proper division of time and labour, so that the principal work of the Divers in inserting charges for blasting, slinging stone, &c., may be done near the periods of the slack water, while the drilling may be advantageously continued during the period of the rapid flow.

Spooning out not necessary in rapid currents.

In a rapid current the stoppage of the drill for the purpose of "spooning out" the hole becomes unnecessary, as the motion of the drill works up the powdered cuttings to the mouth of the hole, whence they are sucked out and carried off by the current.

In a sluggish current, or during slack water, the hose of the air-pump may be introduced, and air forced into the hole, creating a current of water extending to the bottom, which may by these means be cleared of cuttings more thoroughly than by the most careful spooning out.

Arrangement for clearing Drill during the boring.

To attach this arrangement permanently to the drill, we propose to have a small hole along the axis of the drill-shaft, with outlets on each face of the cutter, and a hose attached by a swivel to the upper end of the shaft, through which air or water may be forced to the bottom of the hole, by which means the drill may be kept constantly clear.

Charging the hole.

As soon as the hole is drilled to the required depth, the drill is stopped, the drill-line is detached from the crank-pin and unrove from the ballasted block; the Diver then descends, fastens the derrick-chain, which is lowered to him for the purpose, to the drill-stand, and then signals to hoist away, upon which the whole machine is quickly hoisted on deck.

After an examination of the hole, and clearing away any cuttings remaining in the bottom, the Diver comes to the surface and takes in his hand the charge, contained in a water-tight cartridge, usually of indiarubber, carefully prepared, with Abel's fulminating fusees inside its mouth, hermetically closed, and insulated wires extending to, but not yet connected with, the electric battery on deck, descends and inserts it into the drill-hole, carefully pressing it to the bottom with a rod. The tamping, if any used, is then inserted above the cartridge, and the Diver comes up.

Preparing for firing the charge.

The working vessel is then quickly hauled by the mooring-lines to a safe distance—the capstans working by the steam-engine being used for the purpose—the wires are then attached to the battery, a few turns given to handle (see Frictional Machine, page 24); the operator asks, "All ready?" and, being answered by the Diver, makes the contact, when a shock, followed instantly by a second shock, and the upheaval of the water, announces the explosion of the charge or charges.

Examination of the results of blast.

The working vessel is then hauled back to her position, by steam, as before, and as soon as the water becomes sufficiently cleared of the dark muddy water with which it is filled by the blast, to enable the Diver to see in it, he descends and examines the result. If the blast has been effective, and thrown out a crater from the rock, he signals for stone-chains to be lowered, which being done, he proceeds to sling the large pieces of broken rock one after the other, as they are hoisted and deposited on deck. All the large pieces being removed, he signals for the tub and shovel, and upon their being lowered he proceeds to shovel into the tub the small fragments, and to have them hoisted up and piled on deck until the surface of the rock is sufficiently clear to place the drill for a new hole and another blast.

This operation is repeated, and the work thus progresses.

Working during rough weather.

With some experience, such facility may be attained in drilling as to enable the work to be continued in a rough sea, and during all stages of the tide.

To accomplish this, the slot in the clutch is made of such an oblique form as to permit the clutch to run up the drill-shaft, after tripping, a sufficient distance to accommodate its motion to the upward heave of the vessel in a swell of the sea.

Apparatus allowing for fall and rise of the tide

The peculiar adjustable connection between the drill and the motive power is also so arranged as to afford the means for compensating for the rise and fall of the tide by simply letting out and taking in the line attached to the cleat on the rail of the vessel. In addition, this arrangement also enables the vessel, when threatened by a collision or a sudden storm, by casting off this line, to detach itself entirely from the drill and haul out of danger. After the danger is passed, the vessel can readily haul back again and pick up the drill-line, and at once resume work. This last facility is found to be of much value; rocks generally being in the middle and narrowest parts of the channels, the collisions with passing vessels are frequent, especially during the prevalence of light winds and strong currents.

Cartridges for blasting.

The best is that which combines all the requisites of impermeability to water, lightness, incompressibility, and cheapness.

Lightness and buoyancy of material is required in order that the fragments of the cartridges after an ineffective blast might float out of the hole, and not remain in to choke it and prevent the introduction of a new charge.

Incompressibility, if using gunpowder, is requisite to prevent the powder from becoming caked from the pressure of the heavy column of water, in which state the ignition from the fuses or exploders is slow and incomplete, but we should generally advise the use of compressed gun cotton when the effect of compression is rather

an advantage than otherwise. An absolute requisite is that the cartridges must be watertight.

Tin canisters for charges.

Tin canisters should only be used to contain charges for large blasts, in crevices, large seams, or under projecting "faces." They are made of the usual form (Fig. 7), and should be braced crosswise on the inside to prevent being collapsed by the pressure of the water. For seams the canisters are made flat and thin, and braced also in the interior.

India-rubber cartridges.

India-rubber cartridges of a cylindrical form are used for the drill-holes. They answer better than any other kind. They possess the indispensable requisite of being perfectly watertight, and of leaving after the blast no debris to fill the bottom of the hole. They also, being elastic, yield easily to any irregularities of the hole, so as to be readily pushed to the bottom; the mouth is easily made watertight by being tightly wrapped around the conducting wire with twine, and then covered with a watertight compound.

They have, however, the defect of being compressible, so that at a depth of thirty feet the powder becomes caked and almost as hard as stone, but in using compressed gun-cotton they are undoubtedly almost perfect.

India-rubber cartridges, to contain charges to be placed in seams in the rock, are made long, wide, and flat, and are stitched like a life-preserver in vertical parallel rows, not extending quite to the bottom or top; they answer very well, as they readily adapt themselves to the irregular forms and cavities of seams. The only difficulty is filling them with powder, on account of the small tubes formed by the stitching.

Wood cartridges.

Wooden cylinders may be used, similar in form to our cartridge, Fig. 8. These cylinders are incompressible, also buoyant, so that the fragments, after a blast, float out of the hole; the cost is much less, but they are not watertight. They may be inserted in a thin covering of india-rubber, making them perfectly watertight. They are better than the india-rubber cartridges when using gunpowder.

In addition several fusees or exploders may be used in each of the large charges, so as to give several points of ignition to insure complete combustion.

Means for exploding the charges.

Within each charge was placed one or more fusees containing fulminating powder placed between and around the slightly-separated ends of two fine copper wires (see description of Abel's fuses). The spark produced by the passage of the electric current between these two wire-ends explodes the fulminate and thus ignites the whole charge. The wires in these fuses or exploders are connected with two other wires in an insulating coating of india-rubber or gutta-percha, which extend above the water and to the frictional battery on the deck of the vessel. These wires may be in separate insulated coverings, or both in the same covering.

Great pains must always be taken to make the mouths of the cartridges, where the conducting wires enter the charge, hermetically tight by means of a tight-fitting cork or wrapping of twine, over which a thick coating of a watertight compound of melted india-rubber, lard, and resin is carefully pressed and moulded. All this must be done on the deck of the vessel before the charge is taken below by the Diver.

Conducting wires.

The conducting wire is usually composed of three strands of copper wire, No. 24 being preferable for its conducting power. Two conducting wires are usually used, but at any time if great length is required in order that the vessel may be at a safe distance, in that case a short portion of the second wire of the cartridge is left to project into the water, while a similar portion of wire connected with one pole of frictional battery is allowed to hang over the side of the vessel into the water. When the poles of the battery are connected, as usual, to fire the charge, the explosion takes place instantly, the return current

passing through the water from the end of the wire projecting from cartridge to the end hanging overboard, precisely as though connected by wires.

Frictional Battery.

The frictional battery to be used for these operations is of a very simple construction (see description, page 24). To fire a charge with it, the conducting wires from the fuses or exploders in the charge are first attached to the two knobs of the instrument, a few turns—not more than fifty—are given to the handle to generate the electricity; then, everything being "ready," the order to "fire" is given, when the trigger to connect the poles is pressed by the operator, and the explosion takes place.

Metal Tamping.

A gun-metal cylinder, with one end closed, except a small orifice for the conducting wires, has hitherto been the most successful. The upper part of the cartridge fits into the cup of the tamper, and both are lowered into the hole together. In firing, the cup expands like that of a Minié ball, causing the outside of the cylinder to adhere by friction to the sides of the drill-hole.

Wood Tamping.

Where the above tampers cannot be obtained, a hard wood one can be made of the wedge fashion.

General directions.

Good results in blasting are obtained by first exploding in the drill-holes successive small charges without tamping, until seams are started in various directions, and then using heavy charges of gunpowder or gun-cotton, with a good tamping like the gun-metal cylinder, so as to dislodge, if not to hoist out, all the masses of rock that had become disconnected by the seams; but all these operations should be conducted to a great extent according to the position and character of the rock to be removed.

INSTRUCTIONS FOR CLEANING THE BOTTOM OF VESSELS.

The value of the Diving Apparatus for cleaning ships' bottoms.

Since the use of iron in the construction of vessels the fouling of their bottoms from barnacles, seaweed, and incrustations has become a serious matter, both from the loss of speed and the continual expense of docking, so as to clean and put them in a proper state to proceed to sea; on long voyages the loss of speed coming home is so great that in one voyage the expense of the Apparatus would be paid for by the question of time alone. A vessel that left dock, and that steamed and sailed 13½ knots per hour, ten months after, under the most favourable circumstances, was only able to obtain the speed of 8 to 9 knots per hour.

Cleaning the Great Eastern.

To take a point in view, the Great Eastern, after having returned from laying the Atlantic Cable, was put under the hands of the Divers, incrustations were found to the thickness of one foot, and Captain Halpin informed us that in the passage to Portland she had gained 2 knots in speed since her cleaning; further to prove the utility and facility of the Diving Apparatus in cleaning ship bottoms, this huge vessel was cleaned from stem to stern by six Divers in one month. We also sent a professional Diver and Apparatus with her to Bombay, that she might be cleaned out there if necessary, and we should advise that an Apparatus should be supplied to every iron vessel, and one placed at every station, for repairing vessels under the water-line.

Arrangement to be made before cleaning ships' bottoms.

A rope ladder is constructed, with wood or iron rounds; it must be long enough to pass under the keel to about 3 feet above water-line on either side. A whip or tackle is fastened to each end of the ladder. The ladder is bent round under the vessel, and the whips or tackle are drawn tight, so that the ladder may be close to the vessel on the side on which the bottom is to be cleaned.

Construction of ladder.

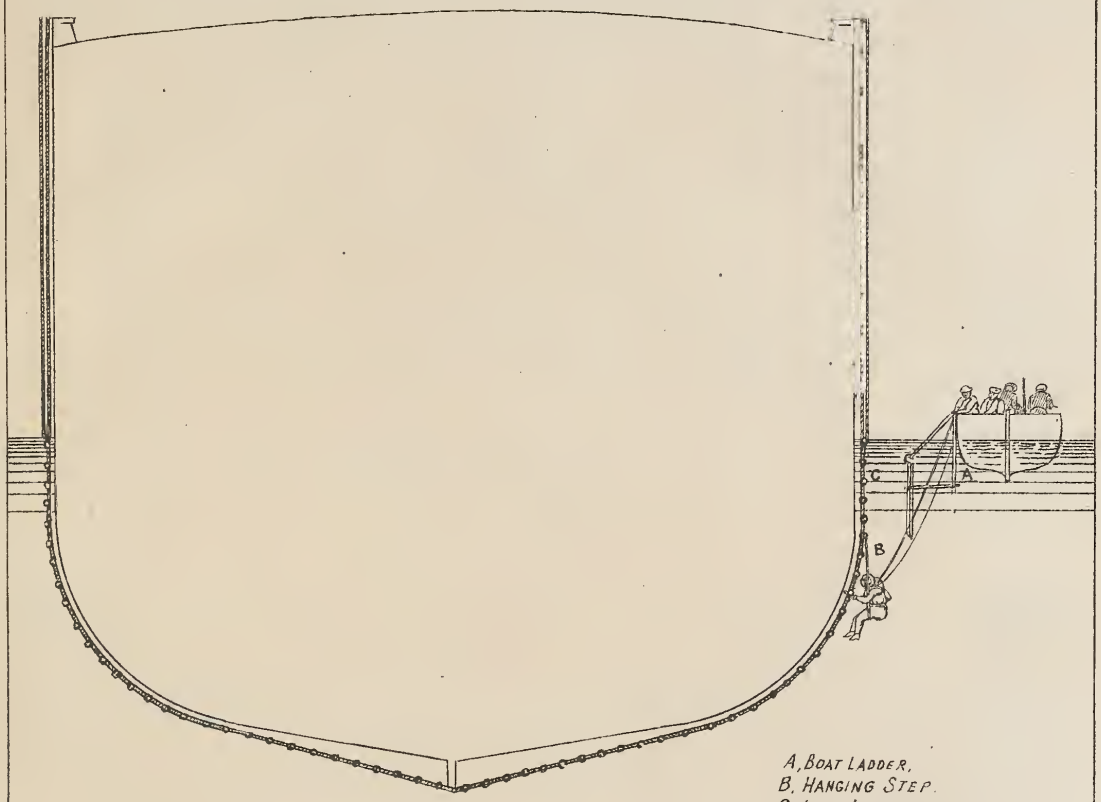
A ladder 50 feet long is sufficient for the largest ironclads. The rounds should be about 13 inches apart, except the two nearest the water-line, which should be about 10 inches apart; with the rounds so spaced it permits the Diver to descend and ascend with facility. A knot of wood or a thick knot or buffer of cord is fastened to the ladder on the side of each round to prevent it being too close against the vessel's side. Unless this precaution be adopted the Diver will not be able to hook the hanging stage on and off easily. The rounds of the ladder are made about 27 inches to 28 inches long, so that the Diver may be able to clean a width of surface from 8 to 9 feet without shifting his ladder.

Hanging stage or step.

The Diver takes down with him under water a hanging stage or step (shown Fig. 9). The stage or step consists of an iron bar or a strong wood round about 30 inches long. It is suspended in a horizontal position by a goose-neck rope or triangular rope support, hung from a hook about 30 inches above the bar. This stage, or bar, is intended as a seat for the Diver. As soon as the Diver gets under water he hangs the stage by its hook to a round or bar of the ladder. He should be always outside the ladder, and seated on the stage he can move from one round to another according as the nature of his work may require.

SIEBE & GORMAN,

Submarine Engineers,



A, BOAT LADDER.
B, HANGING STEP.
C KEEL LADDER,

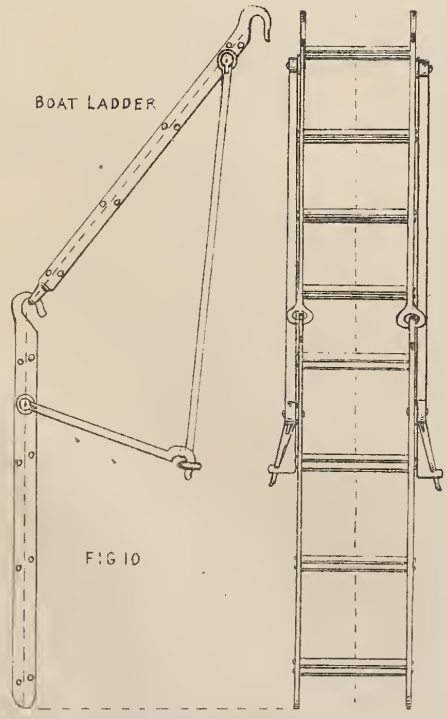


FIG 10

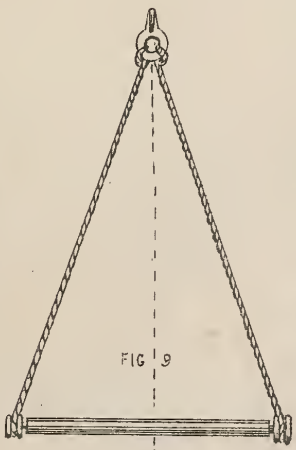
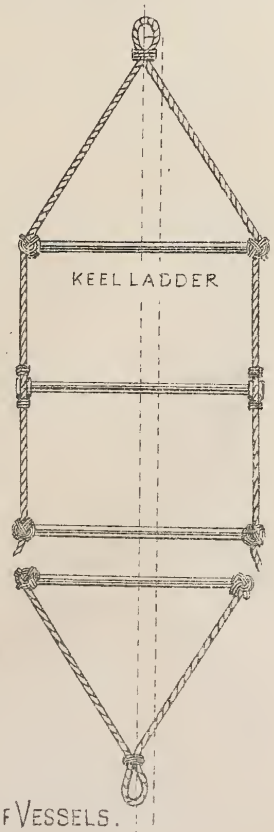


FIG 9



IMPROVED APPARATUS FOR CLEANING THE BOTTOM OF VESSELS.

C. HARRIS LITH

W. LEN BOWLES IMP.

5, DENMARK ST. SOHO, LONDON.

Boarding ladder.

The air-pump being on deck, a boat is used to enable the Diver to go into the water and to come out. If it is fine calm weather, the air-pump may be put in one of the ship's boats. The ladder is such as is used on land, or one of the engine ladders, long enough to be submerged to a depth of 4 to 5 feet, is employed. An iron or wood rod is bent into an arched form, about 3 feet long, so as to give the necessary inclination (as shown Fig. 10). This ladder is lashed or made fast to the side of the boat. The Diver dresses himself in the boat, and descends by the ladder, which is placed opposite the rope ladder (described as being passed under the ship's bottom), so that he has only to turn to get on the latter ladder, and go under the vessel. The arrangement is very important, and were this ladder not used, the Diver would find it very arduous and irksome to have to hoist himself on board the boat with all his weights on him. The boat ladder should be immersed to a sufficient depth to enable the Diver to get his foot on to the first step without any effort.

Instruments used for cleaning.

1st. A couch-grass brush.
2nd. A brush made of brass wire.
3rd. A mop, weighted with lead.
4th. An iron or brass scraper.

Preparations for cleaning.

When the Diver is dressed he attaches to his wrist the cleaning tool he means to employ, and then goes down the boat ladder, and takes hold of the keel ladder and the hanging stage. He goes to the part at which he is to work, and hooks the hanging stage on a round of the ladder, passes his legs over the stage, and seats himself thereon, and in that position he begins to work.

Cleaning.

He cleans the surface as far as his arm can reach on the fore side of the ladder, then between the ropes forming the ladder, and next as far as his arm can reach abaft the ladder. When he has cleaned one part, or section, he ascends, and orders it to be moved forward the required extent fore or aft, as the case may be, when it is made fast by the men on board. Meanwhile the Diver can remain at the water-line, seated on the boat ladder or on any part of the keel ladder, should he wish to give directions by signals for the moving of the keel ladder.

Quantity of work that may be done.

A practised Diver can work from 4 to 7 hours daily below the bottom of a vessel—2 to 3½ in the morning, and the same time in the afternoon—and can clean from 7 to 15 square yards per hour, according to the condition of the bottom.

Cleaning iron plating.

The couch-grass is used to clean the ordinary plating, painted with minium, and on which there is only slime or at the utmost mussels or barnacles.

The Diver fastens the brush to his wrist by a metal chain, and then brushes the plating. During the work he remains seated on his stage, just as if he were cleaning the vessel in dock. He can also use the ordinary deck mop weighted with lead. Divers should be recommended to brush the plating as lightly as possible, so that they may not brush off the minium. When the minium is well laid on, the couch-grass brush leaves a layer of paint on to protect the iron.

Cleaning copper sheating.

Copper sheating is also cleaned by a brush or a broom or mop in a like manner. If the ship's bottom is in a bad condition, the brass-wire brush must be used to remove the small shells or the various very adhesive bodies. Care should be taken not to scratch the copper. Sometimes when the vessel is very foul, and the bottom incrusted, the scraper must be employed.

SHIP RAISING.

Ship-raising.

There are many means of raising sunken vessels, which have been all more or less attended with success. Of the many applications we shall confine our description only to those that have been carried out in actual practice. Small vessels can be raised by the use of empty casks placed in the hold, and with the aid of lighters moored over; but these can be only used where there is a rise and fall of tide; chains from the lighters are attached or passed under the vessel during the low water, and made fast to the lighter. With the rise of tide and increased buoyancy given by the casks she will be probably lifted on the top of the tide; bring her in shore till she touches bottom, when the same process must be continued until she is brought high and dry or in dock. Another method, which has been applied with great success by Mr. W. B. Caulfield, is the employment of indiarubber caissons or air-bags, which are placed in the hold or attached to sides of sunken vessels, and when fixed in position the whole of them inflated from a powerful air-pump. The following vessels were raised by those means:—viz., the Prince Consort, at Aberdeen, an iron paddle steamer of 607 tons; dead weight lifted was 560 tons, including engine and boilers; the brig Ridesdale, sunk off Calshot Castle, 170 tons burthen; H.M. gun-brig Partridge, 180 tons; and the brig Dauntless, 179 tons, in the Victoria Docks in 25 feet of water. The whole of the apparatus employed during these operations never exceeded a lifting power of more than 500 to 600 tons. Another method employed, and which resulted in complete success, was the raising of the iron steam-ship London, at Dundee, by Messrs. Gourlay. Divers were sent down, and all openings were made water-tight, a large shield, weighing 5 tons, being placed over the damage she had received from a collision. Several powerful water-pumps communicating with the hold were set in operation; in the course of two hours she had risen 4 feet; eventually she was taken in tow by two steam-tugs, the pumps being worked the whole time, and was safely docked to undergo a complete renovation.

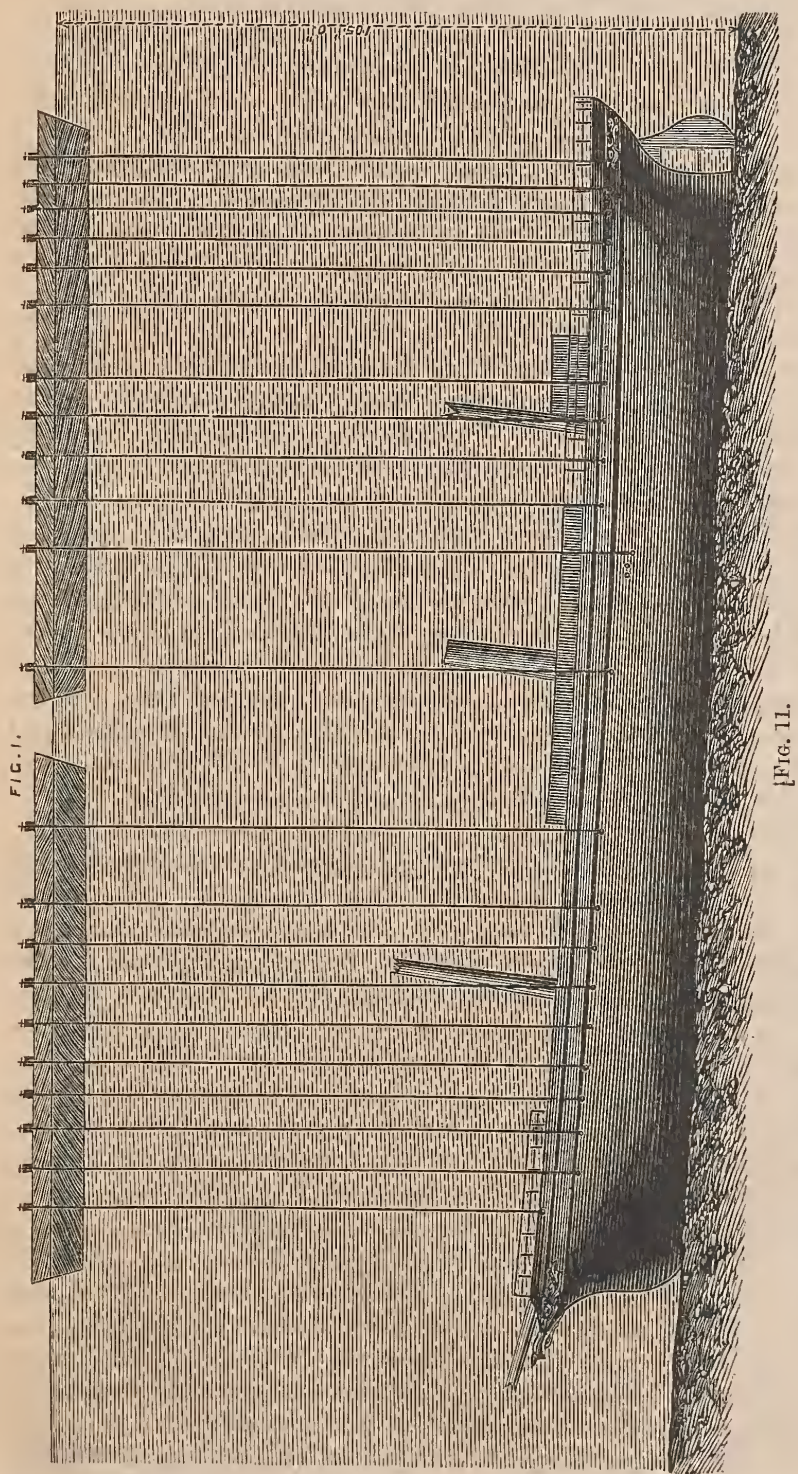
Raising by air caissons or bags.

The employing of water-pumps.

Ship-raising at Sevastopol

Colonel Gowan's operations in the harbour of Sevastopol may perhaps be cited as one of the most successful methods hitherto employed in raising large war vessels. One of them, the Vladimir, weighed about 5,000 tons, being entirely filled with mud. For these operations he constructed four to six large caissons, about 100 feet long, 65 feet width, and 22 feet depth. At one end of the caisson were fixed two wheels on iron pedestals, over which the iron chains passed. The caisson being constructed in water-tight compartments, water was let in the after compartments to counterpoise the lifting weight. On each caisson was fixed a portable steam-engine of 15 horse power, to work the powerful centrifugal pump and also the winch. The chains were made of the best Low Moor iron, 2½ inches diameter. In every case they passed under the keel, the vessel being slung in the four or six chains according to its size. Great difficulty was experienced at first in passing the chains under the keel, but by means of a scraper, which was pulled backwards and forwards, sufficient passage was made to pass first a light chain and ultimately the heavier one. Most of the vessels were lying in 20 feet of mud. During the heavy weather the caissons had only to be submerged where they were moored to ride out the heaviest gale. The whole of these operations were successfully undertaken at a depth of 62 feet under water.

SHIP RAISING BY MEANS OF PONTOONS.



[Fig. 11.

RAISING THE STEAMSHIP TARANAKI, AT TORY CHANNEL, NEW ZEALAND.

The screw steamer Taranaki, of 299 tons register, was wrecked and sunk in Tory Channel, Queen Charlotte's Sound, New Zealand, on the 19th of August, 1868.

The wreck lay in 105 ft. of water at high water, in a sheltered position at Bowden's Bay in the sound. The bottom where it lay had a rise of 6 ft. in the vessel's length, and went on at this slope ahead for about 60 ft., when it rose suddenly up a steep bank, inclining with a rise of 30 ft. in the length of the vessel (some 190 ft.). This bank got still steeper near its summit, and had over it a depth of water of 21 ft. at high water. The depth then increased to 24 ft., and then shoaled very gradually towards the shore for 600 ft. This bank added much to the difficulty of raising the wreck. The range of tide is small, at springs being 4 ft. 6 in., and at neaps 2 ft. 6 in. Two divers were employed, and an average of fifty-four men worked during the operation. The weight to be raised was approximately 400 tons. The floating power provided was four timber pon-

toons of the following dimensions:—Two of them were 95 ft. long on deck and 91 ft. on bottom, the other two were 85 ft. long on deck and 91 ft. on bottom. All four were 14 ft. wide on deck and 12 ft. 6 in. on bottom, and their depth was 8 ft. They had three watertight bulkheads in each, and had valves in bottom, and pumps. They were built of kahikatea, or New Zealand white pine, at Picton, and cost in all £860. The bottoms, sides, and decks of the pontoons were formed of $2\frac{1}{2}$ in. planking; the side and floor timbers, which measured 8 in. by 6 in., being placed 2 ft. apart, while the deck beams, which measured 7 in. by 7 in., were placed 4 ft. apart. The deck was further stiffened by a 6 in. by 5 in. longitudinal stringer placed beneath the deck beams, and supported by 5 in. by 4 in. upright posts interposed at intervals between it and the keelson. The scantling of the latter was 8 in. by 6 in., and that of the bilge pieces 9 in. by 6 in., whilst at the corners formed by the junction of the sides with the deck and bottom were placed covering planks measuring 14 in. by 8 in. and 14 in. by 6 in. respectively, as shown in the section.

The steamer Ladybird was employed as a tender, and towed the pontoons to the wreck, where they were moored two on each side over the wreck; and across them, and extending over the wreck, lay twenty-two beams of the same timber as the pontoons. Each beam was of two pieces, each 18 ft. × 9 in., and placed on edge 5 in. apart, and bolted together. The ironwork cost £550. The lifting rods were forty-four in number, half on each side of the sunken vessel; they were of round iron $1\frac{1}{4}$ in. diameter, in long links 12 ft. long, coupled by short double links. The top link was divided into three, the uppermost of which was double, composed of two bars, each 4 in. × $\frac{5}{8}$ in., and pierced with $1\frac{1}{2}$ in. holes, $4\frac{1}{2}$ in. apart. This was the fleeting link used for adjustment of length of lifting rod. As the vessel rose, the links, as required, were taken out by the divers. The top of the fleeting link was attached to the lifting screw, which was of $2\frac{3}{8}$ in. iron, and screwed for a length of 2 ft. $3\frac{1}{2}$ in., with four threads to an inch. A nut on this was worked by two or sometimes three men with a lever, 5 ft. long, of $1\frac{1}{2}$ in. iron, with an eye fitting over the nut. The nut bore on an iron washer, resting on a hard wood block, lying on the cross beam. To allow for oscillation of the rod, the washer was composed of two parts; the upper, of wrought iron, was rounded at the bottom and fitted in a turned rounded recess in the lower part, which was of cast iron.

Counterbalance weights poised the rod when adjusting or fleeting the screw; these hung over sheaves in the cross beams between the pontoons; at the bottom of each rod was a strong wrought iron hook, to take hold of the portholes or side lights. This hook was of $3\frac{3}{4}$ in. × 1 in. iron, thickened where it took hold of the plate of the wreck to $2\frac{1}{2}$ in. An ingenious stop or catch took hold of the lower edge of the porthole, and prevented the hook from falling out; this was attached to the hook by two pinching screws, and was adjusted by the diver after the hook was placed; it was found to act well. An open iron cage was let down for the divers to stand in, and adjusted from the pontoons to the position wished. In lifting the wreck all the screws on one side were raised one foot, or half the lift: then those on the other side taken up two feet, or the full lift, and then the remaining foot of lift on the first side taken up. In fleeting, four screws were fleeting at once, one in each pontoon at alternate ends.

The party for raising the Taranaki left Wellington on the 23rd of June, 1869, and got the pontoons and the Ladybird moored in position, and all the rods fixed and gear ready, by the 7th of August, when the first lift was made by letting water into the pontoons, and pumping out as the tide rose, having first screwed down tight. She started out of the mud with a sudden lift of 6 in. This day they got a lift of 5 ft. and hauled ahead 50 ft. After getting her to the slope of the bank before mentioned, it was found that when allowed to rest on the ground she slipped back, owing to the rise, the bow being 30 ft. higher than the stern; so after this time they had to lift by the screws, and keep her carried from the pontoons. They lifted at each lift rather more at the stern than the bow, so as to get her again on level keel, and also hauled the stern side-on to the bank. They went on lifting the fore end about 3 ft. and the after end 4 ft. on the days they worked the

screws, till the 21st of September, when she floated over the bank, and went some 300 ft. ahead towards the shore.

On the 22nd the rail was up to the cross logs, which were then packed up, and by the 26th of September, 1869, the leaks and portholes were stopped up, and the Taranaki pumped out. She was found to have a rent in a plate 3 ft. long by 1 in. wide, and near it a hole 3 in. diameter, with a piece of rock in it; both these were in the engine-room compartment. She had sunk by the stern seven hours after she struck. The fore compartment seems to have remained tight, as the deck-beams and fore-hatches were forced in by the pressure of water when she went down. The boiler was also much damaged by the upper part being collapsed. She had been down over thirteen months in 17½ fathoms of water, and the upper decks were completely worm-eaten by the boring-worm. The hull was coated with barnacle and shelly incrustation; but the engine was uninjured, the bearings bright and clean. The cast-iron work was unhurt, the wrought-iron starting gear tarnished, but not so as to damage it; one of the cylinders was full of water, the other empty. The cargo was sadly deteriorated. She had been raised 92 ft., nearly all by the screws. Her hull is reported quite sound, and she is being refitted and repaired at Wellington. The total cost was close upon £3,000.—*Vide "Engineering," January 21st, 1870, with the kind permission of the Editor.*

Strong Seaman's Chest, containing—

2 Improved Waterproof Diving Dresses, made of Solid Sheet Indiarubber, between Tanned Twill, with Vulcanised Indiarubber Collar and Cuffs.
2 Cuff Expanders.
12 Vulcanised Indiarubber Wristbands.
6 Guernsey Frocks.
6 pair Woollen Drawers.
6 pair Woollen Stockings.
1 pair Large Outside Stockings.
2 Woollen Caps.
2 Cotton Neckerchiefs.
1 Canvas Overall Dress.
30 Fathoms Reversed Laid Line.
39 Fathoms Ladder Line.
1 pair Leather Boots with Lead Soles.
2 Lead Weights with Gun-metal Mountings.
1 Knife in Water-tight Brass Case.
1 Leather Belt, with Gun-metal Pipe-holder.
1 Can of Indiarubber Solution.
1 Sheet of Prepared Canvas.
1 Spare Brass Screw Frame.
2 Spare Glasses.
1 Book of Instruction.

£ s. d.

Price complete . . .

SECOND CLASS IMPROVED DIVING APPARATUS.

A three-motion Diving Machine Air-Pump, with three large-sized Gun-metal Cylinders, Forged Iron Crank (two handles), Fly-wheel, Copper Cistern, with Water Apparatus to keep the Cylinders cool, and an arrangement for examination of Valve without removing the Air-Pump from Chest, the whole fitted in a strong Teak Wood Chest, with Iron Caps to protect the crank ends. (*See description, page* 20.)

The Till fitted in the interior of Chest contains the following:—

3 Spanners.
1 Oilcan.
1 Screwdriver.
2 Double Connecting Union Joints.
Spare Valves and Springs.
12 Spare Helmet Nuts and Screws.

Strong Wood Helmet and Seaman's Chest combined, containing the following:—

1 Improved Helmet, with new constructed Segmental Screw to remove the Head-piece by one-eighth of a turn, Strong Plate Glasses in Brass Frames (the front one unscrews), Brass Collar and Screws, with which the Dress is fastened water-tight, one Outlet Valve, and Gun-metal Inlet Valve, with Regulating Valve Front or Breastplate. (*See description, p.* 21.)
1 Helmet Cushion, stuffed with Horsehair.
1 Helmet Nut Spanner.
90 ft. of Vulcanised Indiarubber Air-Pipe made of Solid Sheet Indiarubber between Canvas, Metallic Wire inside, and Gun-metal Union Joints.
2 Improved Diving Dresses made of Solid Sheet Indiarubber, between Tanned Twill, and Vulcanised Indiarubber Collar and Cuffs.
12 Vulcanised Wristbands.
4 Guernsey Frocks.
4 pair Woollen Drawers.
4 pair Stockings.
1 pair large Overall Stockings.
1 Woollen Cap.
1 Neckerchief.
1 Canvas Overall Dress.
90 ft. Reversed Laid Signal.
1 pair of Large Boots with Lead Soles, or Iron, as ordered.
2 Lead Weights, with Metal Mountings.
1 Knife in Copper Case.
1 Leather Belt, with Gun-metal Pipe-Holder.
1 Can of Solution.
1 Sheet of Prepared Canvas.
1 Spare Brass Screw Frame.
2 Spare Glasses.
1 Book of Instruction.

£ s. d.

Price complete . . .

NEW PATENT DOUBLE-ACTION DIVING MACHINE AIR PUMP.

For supplying one or two Divers the advantages of this pump are that two Divers can work at the same time entirely independent of each other, and when it is necessary for one Diver to descend at great depths, the two cylinders can be connected. This pump requires only two men to work it at any time.

The above pump has been extensively adopted by the Royal Engineers' School of Military Engineering (*vide report in "Times"*—see Extract, page 10), also by J. Coode, Esq., C.E., for numerous harbour works, and by W. Parkes, Esq., C.E., for the Government of India harbour works.

The articles sent to form a complete apparatus for two Divers would be a double suit, as described per Estimate No. 2.

	£	s.	d.
Price complete			
With one complete suit only			
Double-Action Diving Machine Air-Pump and Apparatus, complete for working in 90 feet of water, and applicable to one Diver only, for the use of harbours, docks, bridges, &c., complete, price			
Diving Machine Air-Pump and Apparatus for the use of ironclad vessels, iron steamships, and sailing vessels, as used in Her Majesty's Service and during the clearing of the Great Eastern under the water-line, price complete			
Iron Steps for Boat			
Keel, or Jacob's Ladder			

(*See description, page* 34.)

LIST OF ARTICLES USED IN THE DIVING APPARATUS.

	£	s.	d.
Improved Copper Diving Helmet, with new constructed segmental screw to remove the headpiece in one-eighth of a turn, strong plate glass in brass frames, the front one unscrews, brass straps and screws, with which the dress is fastened water-tight, compensating outlet-valves and gun-metal inlet-valve and front valve			

(*See description, page* 21.)

Lead Weights with Metal Mountings			
Helmet for Open Dresses, the front glass unscrews, with Metal Mountings .			
Spare Brass Screw Frame			
Front Glasses			
Side Oval Glasses			
Inlet Valves			

INDIARUBBER GOODS, &c.

All these goods are of our own manufacture.

	£ s. d.
Patent Vulcanised Indiarubber Diving Dress, made expressly for hot climates (We are the patentees and only makers of this dress.)	
Improved Twill Indiarubber Diving Dress, made of solid sheet indiarubber between tanned twill; Vulcanised Indiarubber Collar and Cuffs . .	
Diving Dress for open Helmet, made of solid sheet indiarubber between twill	
Ditto ditto with Vulcanised Indiarubber Cuffs . .	
Ditto ditto made of waterproof twill	
Vulcanised Indiarubber Rings	
Indiarubber Solution . . . . . per lb.	
Prepared Canvas for repairing dress . . . . . per yard	
Sheet Indiarubber . . . . . per lb.	
Vulcanised Indiarubber Cuffs . . . . . each	
Indiarubber Gloves . . . . . per pair	
Patent Indiarubber Air-Pipe, made of solid sheet indiarubber in and outside, covered with canvas, metallic wire inside . . . . per foot	
Vulcanised Indiarubber Pipe, made of solid sheet indiarubber in and outside, metallic wire inside, $\frac{5}{8}$ . . . . . per foot	
Ditto ditto $\frac{3}{4}$ . . . . . ,, ,,	
Ditto ditto 1 inch . . . . . ,, ,,	
Gun-metal Union Connecting Joints for the Indiarubber Air-pipes, $\frac{5}{8}$ each	
Ditto ditto ditto $\frac{3}{4}$,,	
Ditto ditto ditto 1 inch ,,	
Double Connecting Union Joints . . . . . ,,	
Ditto ditto Male Joints . . . . . ,,	
Lashing Joint to Pipe with Copper Wire and Brass Side Screws . ,,	
Helmet Wing Nuts . . . . . ,,	
Ditto Screws . . . . . ,,	
Ditto Nut Spanner . . . . . ,,	
Valves and Springs . . . . . ,,	
Cuff Expanders . . . . . per pair	

These are used for getting the Diver's hands either in or out of the vulcanised indiarubber cuffs.

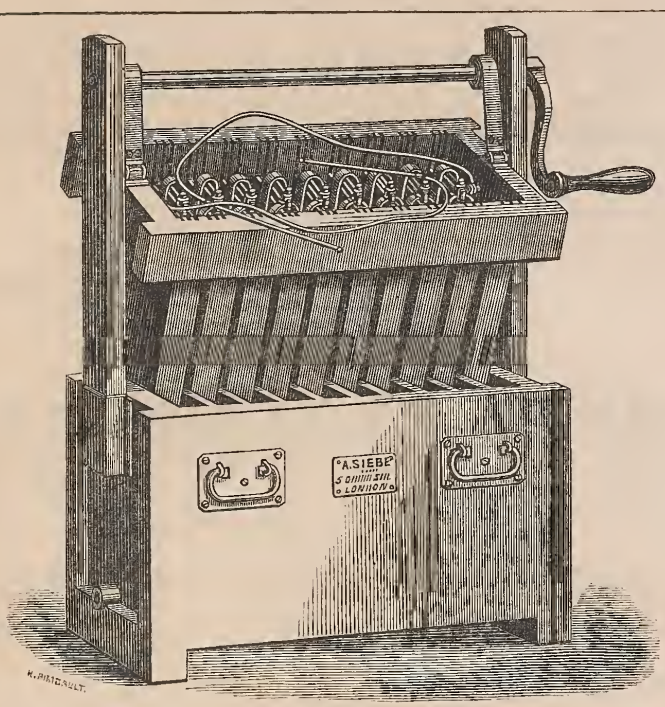


Fig. 12.

APPARATUS FOR EXPLODING UNDER WATER.

	£	s.	d.
Improved Voltaic Battery, consisting of ten Zinc and Iron elements, fitted in Wood trough, with hoisting Gear, &c.	10	10	0

(*See description, page* 22.)

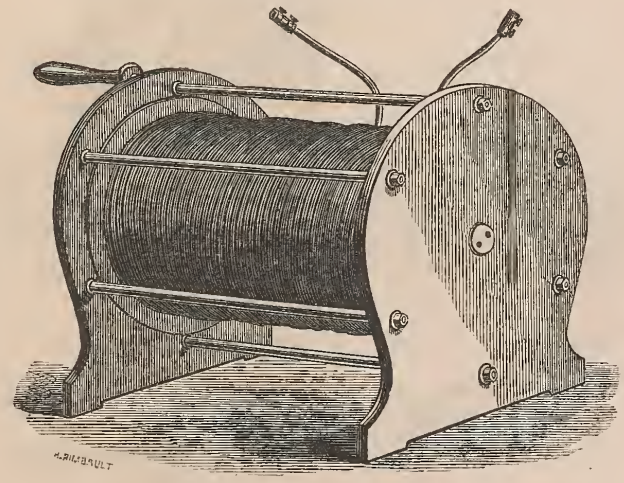


Fig. 13.

	£	s.	d.
Improved Mahogany Reel, with 250 ft. double, Copper Wire, braided over and made Waterproof	10	10	0
Exploding Cartridges . . . . . each	0	2	0
Brass Connecting Screws . . . . . ,,	0	1	0
Fine Platina Wire . . . . . per yard	0	1	0

(*See description, page* 23.)

IMPROVED FRICTIONAL MACHINE FOR SUBMARINE OPERATION.

This machine is of great simplicity and exceedingly portable, requiring no acid or chemical manipulation, and capable of firing 30 fusees at one time. (*See description, page* 24.)

	£ s. d.
Price	
Tripod Stand not included	
Three-strand Copper Wire, covered with Indiarubber and Hemp Rope	per 100 yards
Drum for ditto	each
Abel's Fusees	,,

MAGNETIC ELECTRIC BLASTING MACHINES.

These machines consist of a set of permanent magnet and coils with revolving armature and apparatus to discharge six currents consecutively.

	£ s. d.
Price	
Hemp Rope, containing two conducting Copper Wires covered with Tape and Gutta-percha	per 100 yards
Drum for ditto	each
Abel's Fuse, with Wire Junctions	,,

SIEBE & GORMAN'S
TRAVELLING CRANES FOR SUBMARINE OPERATION AND HARBOUR WORKS.

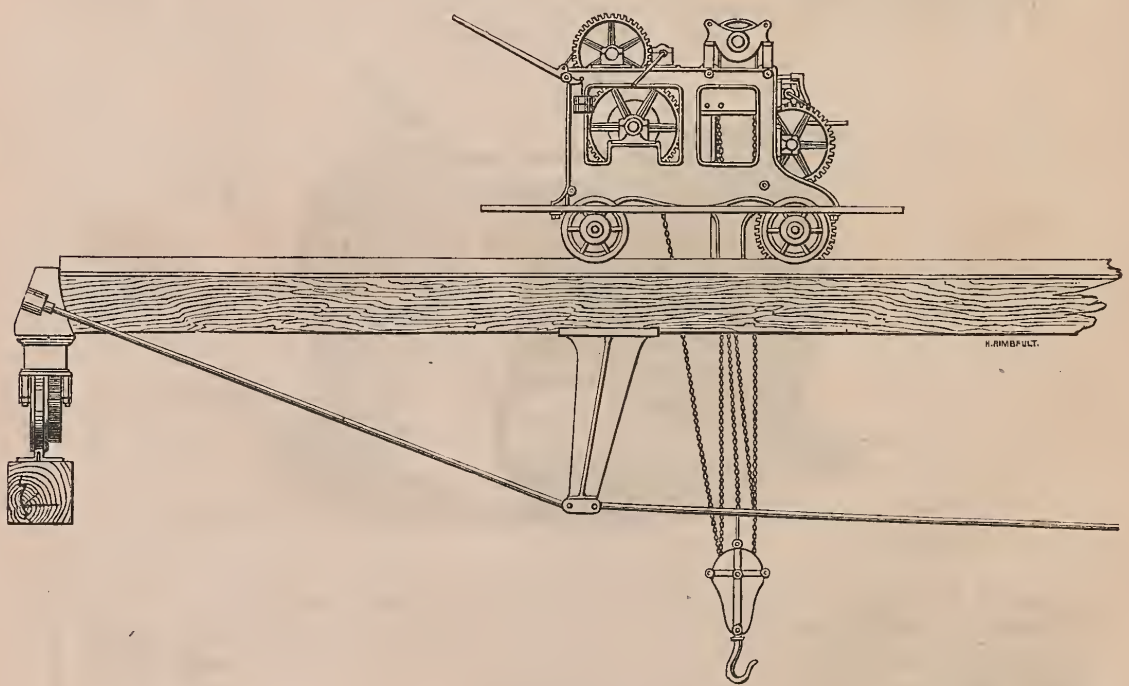


FIG. 14.

Estimates for Travelling Cranes, steam or otherwise, will be sent on application.

A. SIEBE'S

IMPROVED DIVING-BELL APPARATUS

FOR SUBMARINE OPERATIONS.

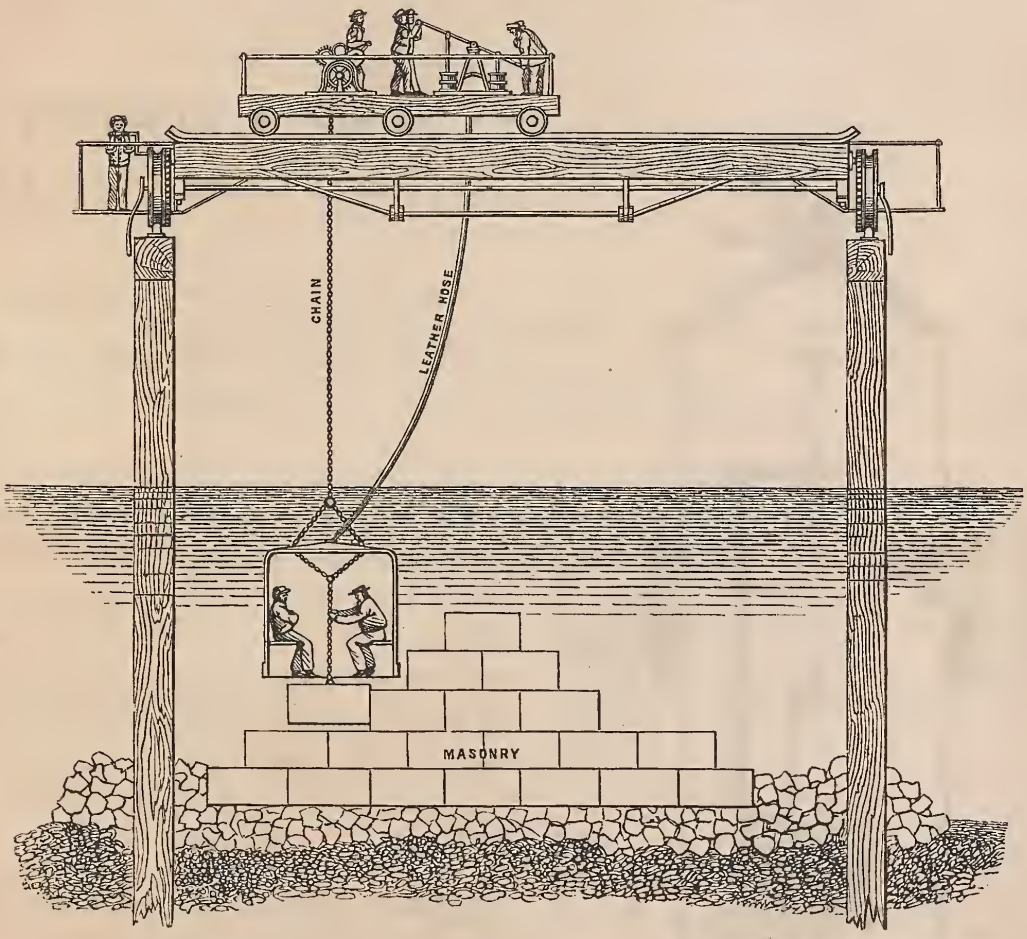


FIG. 15.

Fig. 15. This is a sectional engraving showing SIEBE's Improved Diving-Bell Apparatus in use with divers at work.

	£	s.	d.
Improved Diving-Bell Air-Pump with two 9-inch cylinders each, surrounded with a water cistern to keep cylinders cool, and all fittings complete of the best material and workmanship			
Ditto ditto with two 7-inch cylinders ditto			
Cast-iron Diving-Bell with patent safety valve, strong bullseyes in frame and guards, chain slings, and internal fittings all complete. Size about 6ft. 3in. long, 4½ft. wide, and 5½ft. deep, weight about 6 tons . . .			
Leather Air Hose with internal spiral wire, per yard			

Improved Batteries, Exploding Cartridges, Insulated Copper Wire, Platina Wire, Connecting Screws, and every description of Apparatus for Exploding under water.

Contracts entered into for the removal of sunken wrecks, or rocks from roadsteads, harbours, &c.; the Recovery of Lost Property from sunken vessels, raising ships, stopping leaks, &c.

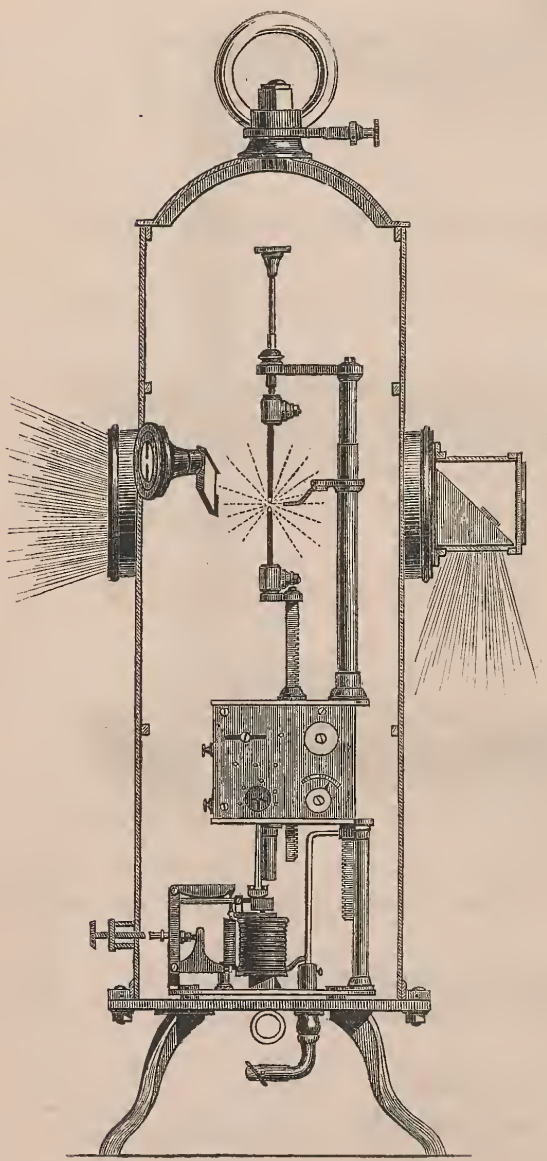


Fig. 16.

SIEBE & GORMAN'S

IMPROVED ELECTRIC LAMPS

FOR

SUBMARINE OPERATIONS,

AND FOR EXAMINING CONSTRUCTIONS UNDER WATER

These Lamps have an illuminating power of 15,000 candles, and are so arranged as to direct the light in four directions, one of them being towards the bottom by means of the reflecting prism A. These Lamps can be carried in the hand of the Diver, which permits him to send the light in any direction. The height of the lamp is 26 inches, and uses carbon points 8 inches in length.

Price £50.

Complete Bunsen Battery, composed of fifty elements, for the above Electric Lamp.

Price £20.

Grove Battery of fifty elements.

Price £47.

The advantage of the above Battery is that it requires less space, and is consequently more portable for removal.

(*See Testimonials.*)

NOTICE.

We have lately introduced a NEW DIVING APPARATUS, especially for Engineers and Contractors, which we can supply complete for £ : :

We have patented a NEW DIVING DRESS, made of Vulcanized India-rubber throughout (Steam Vulcanized), particularly adapted for Hot Climates.

All the India-rubber Goods are of our own manufacture, therefore we guarantee their quality.

SIEBE & GORMAN,

Submarine Engineers,

Undertake all classes of Operations under Water, the Inspection of Works in Progress, Cleaning the Bottoms of Vessels, the Recovery of Sunken Property, the Removal of Wrecks, Boring and Blasting of Rocks and Removal of same, Ship Raising, &c., &c.

ELECTRIC LAMPS LENT ON HIRE.

MANUFACTURERS OF THE

POWERFUL PNEUMATIC PUMPS,

For Diving Bells

AND FOR THE PURPOSES OF SHIP RAISING.

INDIA-RUBBER AIR-BAG PONTOONS SUPPLIED.

A STAFF OF DIVERS.

No. 5, DENMARK STREET, SOHO,

LONDON, W.C.

Printed by Jas. Wade, 18, Tavistock-street, Covent-garden, W.C.